Humboldt-Universität zu Berlin-Geographisches Institut

Climate change adaptation in the Global South

Navigating complexity to build adaptive capacity and resilience to climate change in Northern Ghana

DISSERTATION

zur Erlangung des akademischen Grades

Doktor philosophiae [Dr. phil].

im Fach Geographie

eingereicht an der
Mathematisch-Naturwissenschaftlichen Fakultät der Humboldt-Universität zu Berlin

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Tag der mündlichen Prüfung: 06 March, 2020

Printed and published with the support of the German Academic Exchange Service (DAAD)

Acknowledgements
This PhD research was undertaken at the Integrative Research Institute on the Transformation of Human Environmental System (IRI-THESys) and the Geography Department at Humboldt-Universität zu Berlin. It was funded by the Government of Ghana (Ministry of Education)-DAAD doctoral scholarship program.

I would like to express my profound gratitude to many people who supported me in diverse ways throughout my doctoral studies though it is not possible to name all of them in this dissertation. However, I would like to acknowledge the contribution of a few key individuals. First of all, I would like to express my sincere gratitude to my advisor, Prof. Dr. Jonas Østergaard Nielsen who provided me the rare opportunity to pursue a PhD under his tutelage. Thank you very much for all the support throughout the PhD process. Your patience, motivation and immense knowledge made it possible for me to successfully complete this dissertation. You pushed me time after time to read more and dig deeper, to get out of the „bubble," out of my comfort zone, and to structure my thought. Indeed, I could not have imagined having a better advisor and mentor. I also owe a profound debt of gratitude to my colleagues in the research group for the stimulating and insightful discussions we often had during our monthly meetings. You are as wonderful a group of people as anyone would wish to have! Dr. Cecilie Friis, I am most grateful for your insightful reviews of my first research papers and the synopsis of my dissertation. Özge, Anna, Janine and Haoying, thank you all for being good office companions.

My sincere thanks also go to the administrative staff of IRI-THESys, especially to Olof and Kathrin for the various administrative supports. At the University for Development Studies, Ghana, I would like to express particular thanks to two of my senior colleagues, Prof. Emmanuel Kanchebe Derbile and Prof. Issaka Osumanu Kanton for their friendship and mentorship of my academic career.

I wish to express my deepest gratitude to my family: my mother, Sister Janet (as we affectionately call you), Wilfred and Natalia. You have always been extremely important to me, including during the writing of this dissertation. Last but not least, I whole-heartedly appreciate my lovely wife's support and efforts towards the success of my studies. Lydia, you have always been there for me, you encouraged me and comforted me during turbulent times in my PhD studies.

Abstract
Despite the increasing evidence of climate change impacts on livelihoods and the scores of adaptation measures implemented by governments and non-governmental organizations (NGOs), few measures have actually produced tangible and desirable results around the world. This lacuna has spurred international political debates and established climate change adaptation as necessary in the short term and as a significant future challenge. To date, however, it is still not well known how vulnerability can be reduced or how adaptation to the ever-increasing impacts of climate change can be achieved in resource-scarce regions and globally. Drawing on qualitative case study research methods, this dissertation contributes to the literature on climate change adaptation in developing countries, focusing on Bagri, a small village in the Lawra District of northern Ghana. First, it explores the nexus between climate change extremes and the incremental adaptation strategies of smallholder farmers. It demonstrates that overcoming socio-economic barriers to the uptake of adaptation strategies is necessary but still insufficient condition for achieving successful adaptation outcomes. The results of this study indicate that new barriers to adaptation processes are constantly emerging and climate change extremes are an example of this. Following this, the relationships between social networks and livelihood diversification are explored. From the findings, I see that households that engage in group activities were connected through more social networks. Through these networks, they accessed resources that diversified their livelihoods in order to enhance their adaptive capacity and resilience during climate change. Additionally, the results call attention to the related problems of exclusion and marginalization in social network formation and related livelihood activities that have potentially maladaptive outcomes. Finally, this dissertation addresses questions of why and how adaptation is pursued through collaborative governance, an understudied theme in developing countries. Here, the findings shed light on stakeholder relational dynamics, benefits and failures, and the sustainability challenges of collaborative adaptation governance. More importantly, this study unveils how powerful actors set the agenda, frame problems, and implement rules and incentives contrary to the normative tenets of collaborative governance theory. In conclusion, this dissertation responds to both theoretical and emperical knowledge gaps in the burgeoning climate change adaptation research, and illustrates how invaluable, qualitative case studies can contribute to illuminate some of the elusive themes in the literature and provide evidence for policy making at both local and global levels.

Zusammenfassung
Trotz der nachweisbaren Auswirkungen des Klimawandels auf die Existenzgrundlagen und der Vielzahl von Anpassungsmaßnahmen von Regierungen und Nichtregierungsorganisationen (NGOs) haben nur wenige Maßnahmen weltweit greifbare und wünschenswerte Ergebnisse erbracht. Diese Lücke hat internationale politische Debatten angestoßen und die Anpassung an den Klimawandel als kurzfristige Notwendigkeit und große zukünftige Herausforderung auf die Agenda gesetzt. Bislang ist jedoch unklar, wie in ressourcenknappen Regionen und weltweit die Vulnerabilität reduziert oder die Anpassung an die immer stärkeren Folgen des Klimawandels erreicht werden kann. Basierend auf qualitativen Fallstudien trägt die vorliegende Arbeit zur Literatur über die Anpassung an den Klimawandel in Entwicklungsländern bei; der Fokus liegt dabei auf Bagri, einem kleinen Dorf im Lawra District im Norden Ghanas. Die Studie untersucht in erster Linie den Zusammenhang zwischen Extremen des Klimawandels und schrittweisen Anpassungsstrategien der Kleinbauern. Gezeigt wird, dass die Überwindung sozioökonomischer Barrieren für die Implementierung von Anpassungsstrategien notwendig, aber unzureichend ist. Die Studie zeigt zudem, dass ständig neue Barrieren für Anpassungsprozesse entstehen; Extreme des Klimawandels sind ein Beispiel dafür. Vor diesem Hintergrund werden die Zusammenhänge zwischen sozialen Netzwerken und der Diversifizierung der Existenzgrundlagen untersucht. Es zeigt sich, dass Haushalte, die sich in Gruppenaktivitäten engagieren, durch mehr soziale Netzwerke verbunden waren. Über diese Netzwerke haben sie Zugang zu Ressourcen, die zur Diversifizierung ihrer Existenzgrundlagen beitragen und somit ihre Anpassungsfähigkeit und Widerstandsfähigkeit im Klimawandel verbessern. In den Blick genommen werden zudem Probleme der Ausgrenzung und Marginalisierung in der Bildung sozialer Netzwerke und damit verbundener Aktivitäten, die potenziell schlechte Anpassungsergebnisse zeitigen. Schließlich beschäftigt sich diese Dissertation mit der Frage, warum und wie die Anpassung durch kollaborative Governance, ein in Bezug auf Entwicklungsländer bislang unzureichend erforschtes Thema, vorangetrieben wird. Hier beleuchten die Ergebnisse die Dynamik von Stakeholderbeziehungen, Nutzen und Misserfolg sowie die Herausforderungen hinsichtlich der Nachhaltigkeitsaspekte kollaborativer Anpassungssteuerung. Wichtiger noch, diese Studie stellt heraus, wie mächtige Akteure die Agenda bestimmen, Probleme formulieren und Regeln und Anreize setzen, die im Widerspruch zu den normativen Grundsätzen der Theorie der kollaborativen Governance stehen. Zusammenfassend ist festzuhalten, dass diese Arbeit sowohl auf theoretische als auch auf empirische Wissenslücken im neuen Forschungsfeld der Klimaanpassung reagiert und veranschaulicht, wie qualitativ hochwertige Fallstudien dazu beitragen können, neues Licht auf einige komplexe Themen in der Literatur zu werfen und Einsichten für politische Entscheidungen auf lokaler und globaler Ebene bereitzustellen.

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1.1 Introduction

The mounting evidence of global climate change has stimulated substantial interest among various stakeholders who are working to understand, inform and facilitate adaptation at both global and local scales (Intergovernmental Panel on Climate Change: IPCC., 2018; 2014; Klein et al., 2017; Brown et al., 2019). Adaptation is defined as the adjustment in natural or human systems that moderates harm or exploits beneficial opportunities in response to actual or expected climatic stimuli or their effects (IPCC, 2007; Smit and Wandel, 2006). Adaptation research, practice and policy has become urgent and is viewed as a necessary response to the threat posed by current and future climate change (Dillings et al., 2019; Conway et al., 2019; Brown et al., 2019). Several efforts at the global level, such as the 2015 Paris Agreement on climate change, recognize adaptation as critical, provide clear mandates for nations to implement their pledges or Nationally Determined Contributions (NDCs), and also document and track adaptation progress (Berrang-Ford et al., 2019).

However, despite the growing effort to achieve better adaptation in both the global and local contexts (Niang et al., 2014; Klein et al., 2017; Dillings et al., 2019; Berrang-Ford et al., 2019, Adger et al., 2003; Nalau et al., 2015), the current literature suggests that societies are increasingly creating risk rather than reducing the threats posed by climate change (Klein et al., 2017; World Economic Forum., 2019; IPCC., 2018). For example, the IPCC in its recent special report „Global warming at 1.5 ˚C" warns that at current levels of greenhouse gas emission, the world is unlikely to meet the 1.5˚C goal by 2030 without rapid and unprecedented changes in all aspects of society (IPCC, 2018). Therefore, the deficiencies of existing adaptation strategies and their failure to reduce the likelihood of climate change occurrence and future impacts, remain a major global challenge (Conway et al., 2019; Klein et al., 2017; Dillings et al., 2019; Brown et al., 2019; IPCC., 2018; World Economic Forum, 2019).

In Sub-Saharan Africa (SSA) and elsewhere in the Global South, the need to understand current and future climate change impacts on livehoods (IPCC., 2014; Sylla et al., 2016; Lennard et al., 2018) and facilitate better adaptation measures and policies is more urgent than ever before due to the existence of multiple challenges (Kotir, 2011; IPCC 2014; Niang et al., 2014; Connolly-Boutin and Smit 2016; Schlenker and Lobell 2010; Serdeczny et al. 2016). In SSA, climate change and its impacts are increasing at an unprecedented rate (Niang et al., 2014). Meanwhile, an accurate understanding of current and future climate change and impacts remains elusive (Niang et al., 2014; Lenard et al., 2016), making it difficult to effectively plan adaptation actions and strategies by individuals, local communities, practitioners and policy/decision makers (Yaro et al., 2016; Antwi-Agyei et al., 2014). Additionally, vulnerability to climate change impacts in SSA is also due to high exposure to climate variability and low adaptive capacity (Kotir, 2011; IPCC 2014; Niang et al., 2014; Connolly-Boutin and Smit 2016; Schlenker and Lobell 2010; Serdeczny et al., 2016). Studies have indicated that this has been a result of a high reliance on rain-fed agriculture (Jones and Thornton, 2003; Lobell et al., 2011; Roudier et al., 2011), high poverty levels (Tschakert and Dietrich, 2010), unstable political institutions and states (World Bank, 2014), socio-cultural factors (Jones and Boyd, 2011, Nielsen and Reenberg, 2010), poor market access and inadequate infrastructure (Connolly-Boutin and Smit, 2016; IPCC, 2014).

Given these adaptation challenges, resources from international donors, governments and non-governmental organizations (NGOs) are increasingly being directed to reduce vulnerability (Fellman, 2012; Goldman et al., 2018) by facilitating innovative adaptation strategies and policies to enhance adaptive capacities and resilience in SSA (IPCC, 2007; Kimberly et al., 2019; Ribot, 2011). Indeed, international, multilateral and bilateral

organizations have responded to this challenge by increasing adaptation finance and measures in SSA over the last decade (United Nations Framework Convention on Climate Change, 2015; OECD, 2017).

Nevertheless, several adaptation gaps still persist in SSA (Asante et al., 2015; Osbahr et al., 2010; Mertz et al., 2011; D'haen and Nielsen, 2017; Nielsen et al., 2012; Rasmussen et al., 2018). In order to effectively address these gaps, questions of why vulnerability exists and how to facilitate better adaptation to climate change and variability must be addressed (Yaro et al, 2016; Nalau et al, 2015; Adger et al, 2005). More specifically, this process should be focused on a comprehensive understanding of how vulnerabilities and adaptive capacities are produced and reproduced over time (Osbahr et al., 2010; Adger et al., 2003; Goulden et al., 2013) between diverse social-economic groups and stakeholders and within the active production of lived environments (Kimberly et al., 2019; Taylor, 2015). Indeed, it has been argued the relational dynamics and processes between diverse stakeholders enhance adaptive capacities (Adger et al., 2003; Ireland and Thomalla, 2011; Rockenbauch and Sakdapolrak, 2017; Rotberg, 2013). Unfortunately, these dynamics and processes are still not well understood in SSA or elsewhere in the developing world (Rockenbauch and Sakdapolrak, 2017; Nalau et al, 2015; Antwi-Agyei et al, 2017; Friis-Hansen, 2017; Rasmussen et al, 2018). Thus far, there is an urgent need to look more closely at barriers to adaptation and how social networks, group activities and collaborative adaptation governance could better facilitate adaptive capacities and resilience during climate change and variability.

There is no doubt that the impact of climate change is beginning to manifest in Ghana. Historical climate data for Ghana from 1961 to 2000 shows a progressive rise in temperature and decrease in mean annual rainfall in all the six agro-ecological zones (MESTI: Ministry of Environment, Science, Technology and Innovation, 2013; Minia, 2004). Models project that mean annual rainfall in the whole of the northern savannah will become highly variable and decline between 1.1 per cent and 12.8 per cent between 2020 and 2080. Similarly, the temperature within the same period is expected to increase between 0.8˚C and 5.4˚C (Minia 2004; Owusu and Waylans, 2009). Since the early 2000s, many studies have already reported increasing trend of extreme climate events such as rising temperatures, prolonged droughts, shifts in rainfall pattern, and windstorms in Ghana (Antwi-Agyei et al., 2012; Yaro et al., 2015).

Northern Ghana is highly vulnerable to climate change related shocks and hazards including droughts, floods, strong winds and rising temperatures (Yiran and Stringer, 2016; Yaro, 2013; Antwi-Agyei et al., 2012; Jarawura and Lothar, 2015; Owusu and Waylans, 2009, Minia, 2004). Northern Ghana's vulnerability to climate change has often been attributed to environmental, socio-cultural, and economic factors, as well as and high levels of poverty (GSS: Ghana Statistical Service, 2012; UNDP: United Nations Development Programme, 2018). In Bagri, a small village located in the Lawra District of the Upper West Region where this study was carried out, climate change and variability is occurring. However, the capacity of the villagers to adapt to the ever-increasing impacts of climate change is generally low, leading to challenges to agricultural livelihoods, the mainstay of the village. For example, the majority of the adult populations in Bagri are illiterates (no formal education), there is a lack infrastructure (e.g. irrigation and agricultural storage facilities) and institutional support, inadequate access to climate information and services, which means that adaptation to climate change is a huge challenge. To this end, Bagri and Northern Ghana in general, makes for an interesting case study in terms of how its inhabitants are diversifying their livehoods in order to enhance their adaptive capacities and resilience during climate change and variability. It is this burgeoning research discourse on climate change adaptation that the

papers presented in this dissertation contribute to, by offering both theoretical and emperical insights. This is accomplished by exploring three overarching research questions:

1. Why and how do climate change extremes act as barriers to agricultural adaptation strategies of smallholder farmers in Bagri?

2. Do group activities and social networks foster livelihood diversification to enhance adaptive capacity and resilience during climate change in Bagri?

3. Why, how and under what conditions does collaborative adaptation governance build adaptive capacity and resilience during climate change in northern Ghana?

The results of the research are presented in the following three papers that have been written for publication in international peer-reviewed journals:

Paper A:
Dapilah, F and Nielsen, JØ (2019): Climate change extremes and barriers to successful adaptation outcomes: disentangling a paradox in the semi-arid savanna zone of northern Ghana. *Ambio.* *https://link.springer.com/article/10.1007/s13280-019-01275-x*

Paper B:
Dapilah, F., Nielsen, JØ, and Friis, C (2019): The role of social networks in building adaptive capacity and resilience to climate change: A case study from northern Ghana. *Climate and Development.* https://www.tandfonline.com/doi/full/10.1080/17565529.2019.1596063

Paper C:
Dapilah, F., Nielsen, JØ, Lebek, K., D'haen, SAL (2019): He who pays the piper calls the tune: understanding collaborative governance and climate change adaptation in northern Ghana. *Submittted to Regional Environmental Change*

1.2 Road map of the dissertation

The remainder of the introductory chapter is organized as follows. The next section (section 1.3) introduces the study setting covering the socio-economic and environmental trends in northern Ghana and that of the case study village, Bagri. The history, socio-cultural and economic organization of the village is presented. The theoretical perspectives that guided this dissertation are presented in section 1.4. Finally, in section 1.5, I present the methodology used for the emperical fieldwork (data collection tools and techniques and data analysis methods) and approaches to theory (epistemological and ontological perspective).

Following this introductory chapter, the three papers that constitute this dissertation are presented in full, as they were published (chapter two and three) and submitted for publication (chapter four) in international peer-reviewed journals. Chapter five concludes the dissertation by summarizing and connecting the three papers and providing directions for future research

1.3 The study setting

Northern Ghana is the poorest part of Ghana. In its Human Development Index (HDI), The UNDP (2018) shows human development in northern Ghana in 2014 was low (0.116) compared to average national level (0.575). Poverty levels remained highest in the region, including high levels of youth unemployment, and poor quality of education and healthcare delivery (UNDP, 2018; GSS, 2012).

The lack of development in Northern Ghana lies partly in its historical colonial legacies. Historically, colonial development policies neglected the north in favor of southern Ghana.

Political and economic considerations of British colonial rule have effectively kept northern Ghana as a labour reserve for the flourishing cocoa plantations and gold mines in Southern Ghana. This resulted in the absence of general infrastructure for education, health and transport (Dickson, 1965; Songsore and Denkabe, 1995). Indeed, by the end of the colonial era, the Northern Territories, now present day Northern Ghana lagged behind the rest of the country in terms of income per capita, and access to measures for addressing basic needs (GSS, 2012; UNDP, 2018; Songsore, 1992).

Moreover, the geography (e.g. location and environmental conditions) and socio-economic (e.g. occupation) characteristic of the population have to some extent contributed to a lack of development in Northern Ghana (Yaro, 2013; UNDP, 2018, Songsore and Denkabe, 1995). Geographically, the agro-ecological climatic conditions of the zone include extreme weather patterns, intense dust and heat conditions and desertification (MESTI, 2013). It has a single rainy season from April to October, with average annual rainfall of about 1100 mm. This is followed by harmattan, a prolonged dry season characterized by cold and hazy weather from early November to March, and followed by an intense season of warm weather that ends only with the onset of early rainfall in April. Economic activities, mainly agricultural livelihoods in the region have evolved around the uni-modal rainfall pattern (Owusu, 2017). This is accompanied by a lack of transport services and key facilities for agricultural storage, equipment (e.g. tractors, silos) and irrigation infrastructure such as dams. However, over the last four decades, climatic changes and variability have negatively affected ecosystem provisioning services and livelihoods that are based on agriculture, with implications for crop farming and livestock rearing due to overdependence on rain-fed agriculture (Yaro, 2010; Owusu and Waylen, 2013).
Finally, the geography of Northern Ghana, together with the economies of spatial agglomeration, have contributed in part to low investment in private finance in Northern Ghana. In comparison to the historically more developed urban settlements in the south which are also closer to the coast, Northern Ghana is still predominantly rural (GSS, 2012). The presence of raw materials such as timber and cocoa together with access to road infrastructure including seaports in Accra-Tema, Takoradi and Kumasi enclaves, otherwise known as the „Golden triangle" has favored economies of spatial agglomeration with a large presence of private investments in industrial activities in the south compared to the north (Songsore, 2010). These drivers of socio-economic disparities and underdevelopment are indeed, mutually reinforcing. Therefore, it is particularly important to understand vulnerabilities and adaptive capacities to increasing climate change and variability in resources-scarce regions such as northern Ghana.
The emperical fieldwork was carried out in the Upper West Region of Northern Ghana between February and July of 2017 and covered four districts (Lawra, Jirapa, Nadowli-Kaleo and Wa) and one village, Bagri. The Upper West Region was carved out of the erstwhile Upper Region in 1983 with Wa as its regional capital. The region consists of eleven District and Municipal Assemblies (MMDAs) covering a geographical area of 18,476 Km^2 and about 12.7% of the total land area of Ghana (GSS, 2012). It shares a border to the north with Burkina Faso, to the east with the Upper East Region, to the south with Northern Region and to the west with Côte d"Ivoire.

Bagri, the village studied is located in the Lawra District and lies approximately on latitude 10˚43′ north and longitude 2˚53′ west, about 15 km away from Lawra town. Bagri consists of 198 households and has a population of 1,040 (Male: 514; Female: 526) (GSS, 2012) (Figure I-1). The village is mainly inhabited by the Dagara, the most dominant ethnic group in the Upper West Region (GSS, 2012). The Dagara language is part of the Mole-Dagbani speaking groups of languages which include Dagbani, Buli, Kusase, Talensi, Mampruli and others.

Other variants for this ethnic group are Dagaaba and LoDagaaba (Goody, 1957). However, a distinction is sometimes made between the Dagaaba who live around Jirapa, Nadowli, Wa and the Dagara of Lawra-Nandom areas (Lentz, 2006). I refer to the people of Bagri as Dagara in this dissertation.

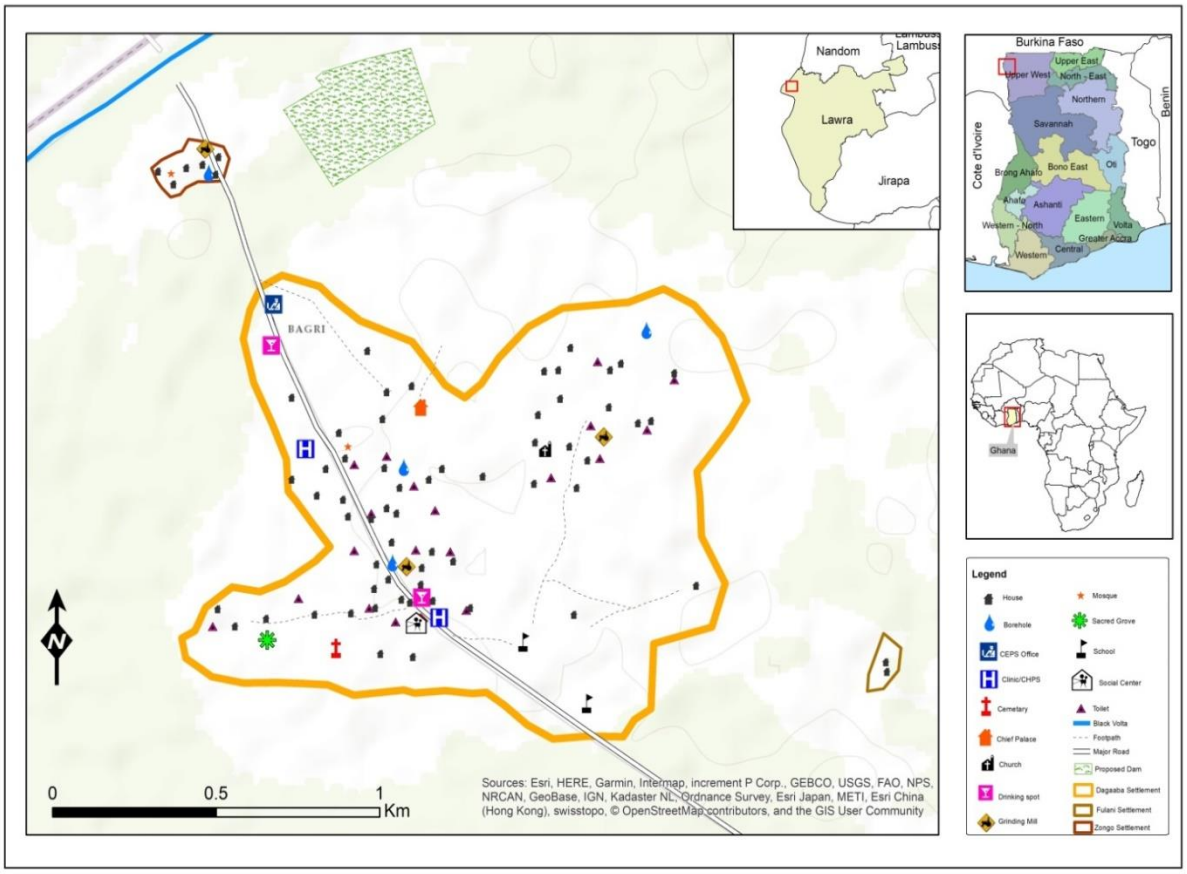

Figure I-1: Map showing spatial organization and location of Bagri

Over the past two centuries, the Black Volta Region, which includes what is now south-west Burkina Faso and north-west Ghana, has been a site of increased agricultural expansion of Dagara speaking groups (Kuba and Lentz, 2002; Lentz, 2006). Oral accounts from the elders of Bagri recount that they migrated from Bakye in present day Burkina Faso to Nadowli, and then to Lawra and Bagri. The name Bagri literally means a pond. The presence of a pond was the main attraction for the first settlers, the Nayuo family from Lawra.

The two main Dagara clans living in Bagri are the Kuseilee and Metholee. Other minority ethnic groups include the Hausa, Wangara, Fulani and Waala. Baba Baba Ali an elder Hausa man, for example, claimed that the Hausa ethnic group migrated from Nigeria to settle in Bagri about a century ago due to the presence of the Black Volta River and in order to fish and trade, their main occupations. According to Kuba and Lentz (2001), one criterion for defining a particular settlement as Dagara is the existence of a Dagara earth-shrine (*Tingan*) that is linked to ritual parish and is served by a custodian, the *Tingan sob* (owner of the earth or earth-priest). In Bagri, there exist a Tengan *and a Tingan sob* (See Plate I-1). The spatial organization of the village neatly follows the ethnic, religious and occupational differentiation/groupings that area shown in Figure I-1. The Dagara mostly practice Christianity and traditional religion with crop farming as their main occupation. The Hausa and Wangara ethnic groups are settled in Zongo (a Hausa word meaning „stranger"s

quarters"). They practice Islam, and are mostly engaged in fishing and trade. The Fulani live at the outskirts of the village, practice Islam and rear cattle owned by the Dagara.

The Tingan of Bagri

Kwasi, Tingan sob of Bagri

Plate I-1: Tingan (earth shrine) and Tingan sob (earth priest) of Bagri

However, the spatial organization and the ethnic and religious differentiation in Bagri are not „cast in steel." Indeed, many Dagara people living in Bagri have learned to speak the Hausa language, and the skills of fishing and trade, and have converted to Islam due the influence of the Wangara and Hausa ethnic groups living there. The case of Seidu Kuukyi, a middle-aged Dagara man, exemplifies the fluidity of social interactions in the spatial organization of the village. After his conversion to Islam and marriage to his Hausa wife, Seidu decided to build a house in Zongo so that he could observe and practice the tenets of Islam while still keeping a room in his Dagara family compound. Likewise, many Hausa and Wangara people have learned the customs and traditions of the Dagara. Indeed, there have been several inter-marriages between the Dagara, Hausa and Wangara ethnic groups.

The political organization of the Dagara is acephalous in nature (Tingan 2002; Kunbuor, 2002) with political authority exercised by clan/sectional heads, chiefs (Naa) and the landlords or owners (Tindana). Lentz (2006) makes a distinction between „first comers" (first settlers) and „late comers" or „new comers" in describing the different roles and authority exercised by these groups in the political and socio-economic organization of Dagara in north-west Ghana. The Kusielee clan who are the first „comers" and the Tingdemee (landowners) of Bagri allocated the land and prescribe rules governing the use of natural resources such as trees and rivers. They also took on the religious role of pacifying the land/earth. For example, during the onset of the farming season Kwasi, the Tingan sob, offered sacrifices that included fowls, goats and local whisky to pacify the earth or the gods of Bagri. These sacrifices and libation are meant to purify the land from evil forces and the occurrences of calamitous events such as drought and are intended to lead to a good harvest. Additionally, there are taboos and sanctions instituted by the *Tingan sob* aimed at ensuring environmental preservation and sustainability. For example, it is a taboo to fell ebony trees (called Gaa in Dagara) in the village.

The Metholee clan constitutes the chiefdom of which Naa Laaripuo the chief exercised political authority and administrative functions. These include the settlement of disputes and conflicts in his court. In general, the chief ensured peaceful co-existence within the village. Naa Kuube-ia Laaripuo and the Tingan sob, Kwasi exercised their authorities in a coordinated manner that involved sectional heads from the minority ethnic groups. Together, they organize the villagers for developmental projects and liaise with both formal state and non-state actors such as the Lawra District Assembly and NGOs in the implementation of

developmental projects in the village. Over the last two decades, the village leadership has worked with several NGOs and state institutions in providing developmental projects including climate change adaptation interventions. For example, the village leadership has made land available and organized communal labour for several developmental projects including afforestation and the construction of schools (Plate I-2) and irrigation facilities. The location of the village in the fragile Guinea savannah zone makes agriculture production challenging in the era of increasing climate change (Yaro et al., 2014). The low socio-economic status of the villagers (Table I-1) coupled with diminishing agricultural yields over the last three decades creates food insecurity, especially during the long dry season between November and March. Additionally, low levels of education and the lack of infrastructure such as roads, modern agricultural technologies such as tractors, silos for crop storage, and irrigation facilities makes adaptation to climate change difficult. For example, about 86.6% of household heads in Bagri had no formal education and no household owned a tractor. , access to social amenities and health services also remains a challenge.

Plate I-2: Basic school facilities provided by the Baptist church in Bagri
Source: fieldwork

The village has a clinic that is overseen by a community health nurse, and as a water source, has only five borehole facilities that run dry during the arid season. Many villagers, women and girls in particular, queue and spend several hours each day in search of water during the arid season. Moreover, households lacked access to sanitation services. Toilets, waste disposal facilities, sewers and drains are not available in the village. This makes it difficult for the villagers to observe proper hygiene waste disposal practices, leaving them, for example, with no other option than defecating in the bush. This leads to high rates of diarrhea, malaria and typhoid among children under the age of six during the rainy season. Childhood malnutrition is also high during the lean season, a period when many household run out of food stock, leading malnutrition. In light of the above, the urgent need to understand vulnerabilities and how to better adapt agricultural livelihoods to climate change is essential in overcoming some of the socio-economic challenges faced by the people of Bagri.

Table I-1: Household and biophysical charcteristics

Household characteristics		N=127
Gender of household head	Male	92.9
	Female	7.1
Age	21-30	11.8
	31-40	18.1
	41-50	15.7
	51-60	47.2
	60+	7.0
Ethnicity	Dagara	62.9
	Hausa	22.8
	Wangara	12.5
	Fulani	1.5
Wealth ranking based on assets	High	12.5
	Medium	41.7
	Low	45.8
Educational status	No education	86.6
	Primary	6.2
	Secondary	5.7
	Tertiary	1.5
Major occupation	Crop production	100.0
	Livestock rearing	73.2
	Fishing	49.6
	Trade/commerce	47.2
	horticulture	23.6
	Agro-based processing	31.4
Group activities and networks	Organized	40.1
	Organic	22.0
	Non-group	37.9
Biophysical characteristics		
Average annual temperature(˚C)	27-36	
Average annual rainfall(mm)	1000-1100	
Agro-ecological zone	Guinea savanna	
Climate	Semi-arid	
Seasons	Wet and dry	

Source: Questionnaire survey 2017; MESTI (2013)

1.4 Theoretical perspective

1.4. 1 Introduction

Irrespective of scale, global or local contexts, it is imperative that we understand societal or institutional adaptive behaviour in response to climate change. This can largely be achieved through advances in the existing theoretical and applied bodies of work on the human dimensions of climate change. This section provides the theoretical perspectives of this dissertation. The first section focuses on three key terms in the climate change literature: vulnerability, adaptation and resilience. The second section introduces and discusses the literature on livelihood diversification as a means of reducing vulnerability, and facilitating adaptation/adaptive capacity and resilience during climate change. These theoretical perspectives are of particular relevance and serve as cross-sectional themes in all three research papers that comprise dissertation. The three papers specifically explore: climatic

barriers to adaptation (chapter two), the role of social networks in building adaptive capacities during climate change and variability (chapter three) and collaborative adaptation governance (chapter four).

1.4.2 Human dimensions of climate change: vulnerability, adaptation and resilience

Climate change refers to long-term changes in weather parameters in relation to human experience (IPCC, 2007; Jasanoff, 2010; Brace and Geoghegan, 2011). These changes not only include temperatures but also other properties of the climate system such as precipitation, sea levels, weather extremes and wind speed (IPCC, 2014). In the broad sense, „human dimensions of climate change" refers to human capacities, exposure and response to climate change (Nelson et al., 2007; Adger et al., 2003; IPCC, 2018). Goldman et al. (2018) and Wainwright (2010) argue that it is these dimensions of climate change, rather than climate change uncertainties per se, that have animated debates about adaptation capacities and responsibilities in key climate agreements at the global scale. Three key concepts: vulnerability, adaptation and resilience have dominated academic and international policy debates on the human dimensions of climate change (Berkes and Ross, 2016; Nelson et al., 2007; Adger et al., 2000, 2005; Berkes et al., 2003; Conway and Hulme, 2003; Smit and Wandel, 2006; Canon and Muller-Mahn, 2010).

Firstly, *vulnerability* is a central concept used in research and policy contexts where increasing attention is being paid to understanding its relation to adaptive capacity or resilience to climate change (Tschakert and Dietrich, 2010; Chambers and Conway, 1992). In the literature on climate change, vulnerability is defined as the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes (Engel, 2011; Smit and Wandel, 2006; Thomas et al., 2018). It is seen as a function of the character, magnitude, and rate of climate change as well as variation to which a system is exposed (Fellman, 20102). The IPCC (2007) highlights three main components of vulnerability: exposure, sensitivity, and adaptive capacity. Exposure represents a background climate condition but also the degree and duration of variation of climate stimuli (Adger, 2006, Fellman, 2012). Sensitivity of a system to climate change refers to the degree to which a system is affected either adversely or beneficially by climate change and variability (IPCC, 2007, Smit and Wandel, 2006). These effects can be direct (for example, damages to as a result of floods and drought) or indirect (a decline in crop yields). Therefore, sensitivity is the overall responsiveness of a system to climatic influences and the degree to which it might affect its current form and function (Fellman, 2012, IPCC, 2007). Exposure and sensitivity together describe the potential impact that climate change can have on a system (Fellman, 2012). The vulnerability of agricultural livelihoods may be described in terms of exposure to increasing temperatures, the sensitivity of crop yields to climate extremes such as drought and the ability of farmers to adapt to the effects of this exposure and sensitivity by, for example, planting crop varieties that are more heat-resistant or switching to another type of crop.

Nevertheless, it is often noted that even though a system may be considered to be highly exposed and/or sensitive to climate change, it does not necessarily mean that it is in fact vulnerable (IPCC, 2007; Fellman, 2012). This is because neither exposure nor sensitivity account for the capacity of a system to adapt to climate change (i.e. its adaptive capacity). Vulnerability is the net impact that remains after adaptation is taken into account (Adger et al., 2007, Fellman, 2012, IPCC, 2007). Against this backdrop, Thomas et al. (2018) identified four broad themes as particularly helpful for understanding social aspects of vulnerability to climate change to include the access to resources, governance, culture, and knowledge and information on climate change. All three papers presented in this dissertation are concerned with the analysis of these factors.

Secondly, the concept of *adaptation* has been used more and more, and has come to dominate the climate change literature since the mid-1990s (Adger et al., 2003; Ribot, 2011; Brown, 2011, Klein et al., 2017). The term has different meanings, interpretations and applications in the literature (Smit and Wandel, 2006, Nelson et al., 2007, Adger et al., 2009; Kates et al., 2012). A fundamental distinction is made between adaptation within natural versus human systems (Adger et al., 2003, Berkes et al., 2003). In natural systems, adaptation is entirely reactive, whilst in human systems, it is either reactive, anticipatory or both, before and after a shock (Tschakert and Dietrich, 2010, Nelson et al., 2007). Adaptive behaviour in human systems is seen as a continuous process, with defined intents and purposeful adjustment to changes, and with no defined end point (Smit and Wandel, 2006; IPCC, 2007).

The IPCC (2002:982; cf. IPCC, 2007) defined adaptation in the context of global environmental change as an adjustment in natural or human systems that moderates harm or exploits beneficial opportunities in response to actual or expected climatic stimuli or their effects. A more comprehensive definition has been offered by Nelson et al (2007:395) as „the decision-making processes and the set of actions undertaken to maintain the capacity to deal with future change or perturbations to a socio-ecological system without undergoing significant changes in function, structural identity, or feedbacks of that system while maintaining the option to develop". In this sense, adaptation involves building adaptive capacities of individuals, groups and organizations in order to increase their ability to adjust to changes by implementing adaptation decisions (Nelson et al, 2007, Adger et al, 2003).

Moreover, there is a close relationship between adaptation and adaptive capacity. Adaptive capacity refers to the preconditions that are necessary to enable adaptation to take root, and involves social, economic and physical elements (Adger, 2000; Tompkins and Adger, 2004). Thus, adaptation is distinct from adaptive capacity (Gupta et al., 2010). Gupta et al. (2010:461), drawing on existing definitions in the literature on institutions has defined adaptive capacity as „the inherent characteristics of institutions that empower social actors to respond to short and long-term impacts either through planned measures or through allowing and encouraging creative responses from society both ex ante and ex post".

The notion of adaptive capacity from human systems perspectives is determined by a suite of resources (technical, institutional, demographic and financial) held and the social processes and structures through which they are employed and mediated in both temporal and spatial forms (Adger, 2000; Tompkins et al., 2004). Adaptive capacity is scale and place specific and varies among individuals, social groups and individuals in a particular community over time (Adger et al., 2005, Osbahr et al., 2010, Nielsen and Reenberg, 2010). On the other hand, in socio-ecological systems research, adaptive capacity is viewed as the ability of a socio-ecological system (or the components of that system) to be robust in the face of disturbance and capable of responding to change (Walker and Salt, 2006). Four general factors have been identified by Folk et al. (2003), to foster adaptive capacity in socio-ecological systems: (i) learning to live with the change and uncertainty (ii) diversity in its various forms that increases the options for coping with shocks and stresses (iii) different types of knowledge for learning to understand the feedbacks and temporal dynamics and (iv) creating opportunity for self-organization and cross-scale linkages.

Finally, the concept of *resilience*, a core theme of this dissertation has a long and diverse history spanning several centuries (Klein, 2000; Alexander, 2013). Resilience has been in vogue and received considerable attention and use in both scholarship in the adaptation to climate change literature as well as policy making (Holling 1973; Berkes, 2007; Adger, 2000; Folkes, 1998). Its scholarly roots stem from ecology, where it is defined as the persistence of

natural systems in the face of significant change such as fires and floods (Folke, 2006; Maguire and Hogan, 2007).

The broader resilience literature reflects disagreement between static outcomes and dynamic processes (Cutter, 2016; Berkes, 2007). Among scholars, especially in the physical and ecological sciences, resilience is conceived as the ability of a system to return to, or resume, its assumed stable equilibrium state or configuration following a shock or disturbance. The focus is on resistance to shocks and stability near equilibrium. On this thread, both the resistance to disturbance and speed by which the system returns to equilibrium are considered as measures of resilience (Pimm, 1984; Matyas and Pelling, 2012; Davidson, 2010). This notion of resilience has been criticized, as for example, Davidson (2010) questions whether an ability to accommodate shocks or disturbances without experiencing changes to the system should be the preferred option. The omission of multiple possible equilibria and the assumption that it is indeed, possible for a variable to return to a particular equilibrium are both problematic in a social context (Matyas and Pelling, 2012).

In social systems, the concept of resilience is used to connote the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change (Adger, 2000, Cutter, 2016). This perspective aims at enhancing capacities in various systems through dynamic processes that includes feedbacks, adaptive learning and change (Cutter 2016). It is widely acknowledged that, social systems may never reach equilibrium but rather evolve as complex systems that constantly adapt to sustain their development path (Pike et al., 2010; Scott, 2013).

Despite these differences, there exist synergistic relationships between social and ecological resilience, especially in resource-dependent societies (Adger, 2000, Walker and Salt, 2006). For example, Norgaard (1994) argues that, the resilience of social systems is related in some way to the resilience of the ecological systems on which social systems depend. Resource dependency is defined by „the reliance on a narrow range resources leading to social and economic stress" (Adger, 2000:351). Indeed, in the climate change literature there is evidence that the social resilience of resource-dependent societies in developing countries is increasingly compromised (reduced crop yields, unstable incomes and livelihoods) during climate perturbations such as droughts and floods (IPCC, 2014; Adger et al, 2000; Rockenbauch and Sakdapolrak, 2017). Therefore, in this dissertation, the conception of social and ecological resilience provide a guide for the analysis of broad social institutions, including governance, livelihoods and natural resources on which rural societies ultimately depend. Both ecological stability and social resilience are perceived to be desirable social goals in climate change research and policy arenas (Olsson, 2006; Walker et al, 2006; Gunderson, 2003). In this regard, I conceptualized resilience as system-oriented and focused on analyzing the relationship between the components of different social and ecological systems.

In summary, vulnerability is conceptualized as a systems exposure, sensitivity and adaptive capacity to climate change and variability. *Adaptation* is actor-orientated in nature and focused on decision making as well as on the roles of actors and their agency and actions (Nelson et al., 2007, Smit and wandel, 2006). *Adaptive capacity* is the inherent characteristic of a society that fosters adaptation. Resilience is conceptualized as complex systems, focused on the relationship between different systems components (social and ecological) and feedbacks across temporal and spatial scales (Adger et al, 2000; Walker et al, 2006). All three papers of this dissertation use the concepts described above as analytical lenses based on the understanding and consideration of their close conceptual relationships. It is argued that, the dominance of general concepts and frameworks to describe, predict and prescribe human

actions in response to climate change (Swyngedouw, 2010; Nelson, 2007; IPCC, 2014) lead to abstractions of the human dimensions of climate change which exclude the knowledge and experience of many individuals and societies who live with climate change (Goldman et al., 2018). To avoid this problem, this dissertation uses these theoretical perspectives as a guide and to understand the knowledge and experiences of climate change. It also attempts to discover how adaptation measures are implemented and adaptive capacities and resilience are enhanced from the perspective of the people living in Bagri.

1.4.3 Livelihood diversification

Climate and weather events, such as changes in precipitation amount and distribution, short periods of extreme temperatures, and localized strong winds, affects the lives and livelihoods of millions of natural resource-dependent rural populations living in developing countries (Yaro et al., 2014; Nielsen and Reenberg, 2010; Ellis, 2000). Livelihood is defined as „ the capabilities, assets (stores, resources, claims and access) and activities required for means of living" (Chambers and Conway, 1992:7). In SSA, the impacts of current and future climate changes and uncertainties are projected to affect massively agricultural livelihoods (Jones and Thornton, 2003, Lobell et al., 2011; Roudier, 2011, IPCC, 2014). Therefore, there is increasing emphasis on agricultural livehoods that can: (i) cope with and recover from shocks and stresses (Antwi-Agyei et al., 2014; Yaro et al., 2016) (ii) maintain or enhance existing capabilities and assets despite uncertainty (Tschakert et al., 2010; Niang et al, 2014), and (iii) ensure the provision of sustainable livelihood opportunities for future generations in SSA (Ellis, 2000; Connolly-Boutin and Smit, 2016).

In natural resource-dependent societies in SSA and elsewhere in the Global South, diversification of livehoods is regarded to be adaptation in response to local climate variability, recurrent shocks and climate change (Nielsen and Reenberg, 2010; D'haen et al., 2014; Yaro et al., 2016). Livelihood diversification is defined as „the process by which (rural) households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living" (Ellis, 2000:14). Diversification strategies are broadly categorized into on-farm (mix of agricultural activities, e.g. crops, livestock), off-farm (wage or labour exchange within agriculture e.g. income from fuelwood sales and labour), and non-farm activities (non-agricultural income such as rural wage or salary employment) (Barrett et al., 2001; Ellis, 2000). Indeed, many households in SSA strive to achieve livelihood resilience to climate change by means of livelihood diversification (D'haen et al, 2014; Ellis, 2000). In Bagri and many other rural communities in SSA, livelihood resilience or adaptive capacities are largely dependent on the coevolution of climatic and non-climatic factors at both temporal and spatial scales (Nielsen et al., 2012; Antwi-Agyei et al., 2014; Barrett et al., 2001; D'haen et al., 2014). The papers presented in this dissertation add to the human dimensions of climate change literature by specifically highlighting the connections between agricultural adaptation strategies and climate change extremes (chapter two), the role of formal and informal social networks (chapter three) and collaborative adaptation governance (chapter four) play in livelihood diversification and adaptation to climate change in Bagri, northern Ghana.

1.5 Methodology

1.5.1 Qualitative case study approach

This dissertation used the analytical case study methodology derived from social science research inquiry (Creswell, 2009; Yin, 2013). Baxter (2010:82) views case studies as involving „the study of a single instance or small number of instances of a phenomenon in order to explore in-depth nuances of phenomena and the contextual influences on and explanations of that phenomena". Case studies are undertaken within a bounded system, setting and context (Creswell, 2007; Denzin and Lincoln, 2005). This dissertation covered a

single instrumental case study and focused on a single issue (climate change adaptation). I purposively selected my case/setting (Bagri) to explore the issue of climate change adaptation and livelihood diversification. Case study research approaches are well suited for geographical research including the study of human dimensions of global climate change. It is often argued that, while climate change is global, its manifestations are profoundly local (Cruikshank, 2005) and require locally appropriate solutions (Nalau et al, 2015). Therefore, the primary philosophical goal of this dissertation is to have an in-depth understanding of the manifestation of climate change at the local scale in Bagri. I find my case to be valuable, without specific regard to how climate change is manifested in other cases or at the global scale (Lund, 2014). Therefore, achieving an in-depth understanding of my case is crucial to solving concrete/practical problems and/or, broadening our theoretical understanding, or both. Lund (2014:226), for example, argue that, „to understand what case studies are about, it is insightful to locate their contents between the very specific and the very general and as well, know where they sit between the very specific and more abstract".

1.5.2 Approach to theory: epistemological and ontological consideration

Social science research is theoretically informed (Howell, 2013:20). Theories do not only have influence on what is researched but also, more importantly, how the findings are interpreted (Bryman, 2018). The empirical fieldwork was informed and influenced by theoretical perspective in human geography and the broad interdisciplinary fields of human dimensions of climate change adaptation research. The use of theoretical concepts guided this dissertation, i.e. adaptation, adaptive capacity, and livelihood diversification provided the means by which factual evidence was collected and organized for analytical generalization as opposed to generalization (Bromley, 1986; Burawoy; 1991; Yin, 2013). As Yin (2013) suggests, analytical generalization is aimed at corroborating, modifying, rejecting or otherwise advancing theoretical concepts that are referenced in the design of a case study or new concepts that have arisen upon completion of a case study. Creswell (2009:193) argue that „the value of qualitative research lies in the particular description and themes developed in the context of a specific site. Likewise, Howell (2013) view theories as fundamentally situated in specific contexts, experiences and perspectives of people and institutions. This approach to theory allowed me to shed empirical light on advancing the theoretical perspectives considered in this dissertation and beyond the fieldwork setting.

Moreover, social science research embraces different ontological and epistemological paradigms of inquiry (Yin, 2013; Creswell, 2007). This dissertation is based largely on the constructivist paradigms of knowledge development and production (Guba and Lincoln, 1989). In the constructivist paradigm, understanding is a matter of interpretive construction on the part of the active subject and humanity is solely responsible for knowledge development (Howell, 2013). Constructivism understands reality as being locally constructed and based on shared experiences. Accordingly, research results are arrived at through consensus and individual construction, including the construction of the investigator (Silverman, 2018; Guba and Lincoln, 1989; Howell, 2013). For example, the distinguishing features of different epistemological paradigms have been summarized by Navon (2001:624), who state that: „for a rationalist, the mind *unveils* reality, for postmodernists, the mind *invents* reality whereas for constructivist the minds *creates* reality and claims that facts are produced by human consciousness. From a constructivist perspective, reality as a part of human existence is determined and defined through social interactions. Throughout the empirical fieldwork of this study, I focused on learning the meaning of opinions held by participants about climate change and its impacts on their livelihood. Thus, I tried wherever possible to interpret and construct what I saw, heard or was told by my participants. Ultimately, I tried to develop a picture about the issue of climate change that involve reporting multiple perspectives,

identifying many factors that influence vulnerability and adaptation, and generally sketching the larger picture that emerges. Moreover, from a constructivist perspective of inquiry, the research project was constrained by limited possibilities regarding generalizations and causal relationships. I emphasized the temporal and contextual ideographic statements on depth rather breadth and closely followed what Guba and Lincoln (1985:37) suggest when they state: „within the possibility of causal linkages… all entities are in the state of mutual simultaneous shaping, so that it is impossible to distinguish cause effects (Howell,2013; Guba and Lincoln, 1985:37).

1.5.3 Empirical Fieldwork methods

In contrast to quantitative research that involves probabilistic sampling, qualitative case study research tends to involve purposive sampling (Yin, 2007; Silverman, 2017; Lincoln and Denzin, 2005). In order to sample the case village and participants, I used variants of purposive and snowball sampling in a strategic manner that reflected the overarching research questions. In short, the overarching research questions of this dissertation guided the selection of my case study.

The empirical fieldwork of this study was conducted between February and July of 2017 using multiple research methods such as semi-structured interview, participant observation, focus group discussion, informal conversation and a questionnaire survey (see Table I-2). As suggested by Silverman (2018:35), „methods should be our servants not our rulers". Hence, the choice of each of the methods for data collection was essentially influenced by it appropriateness in providing specific answers to the broad research questions of this dissertation.

1.5.3.1 Participant observation

Participant observation was useful as an overarching research method in providing additional answers to my research questions (Yin, 2013). It has its roots in anthropology and involves participating in a situation while at the same time recording what is being observed (Lacono et al., 2009) and is a flexible and iterative method of inquiry and knowledge formation (Clarke et al, 2009). I participated in several activities that the villagers engaged in order to facilitate adaptation. For example, I followed traders to Zambo in Burkina Faso and fishers to Dokyere in the Wa-West District of the Upper West Region of Ghana. I participated in several meetings organized and led by NGOs, including the weekly meetings of the various village savings and loans associations (VSLA) and visits to agricultural fields. This participation provided me with important information on how the villagers engaged in economic activities and negotiated amongst several alternatives in their pursuit of different adaptation pathways. Some of the issues that I observed using this method challenges with transportation, access to tractor services, and crop failure due to drought, floods and worm infestations. Indeed, I could not have had a better understanding of these issues without participant observation.

1.5.3.2 Semi-structured interviews

Semi-structured interviews were an important method of data collection for this dissertation. As a method, it allows the interviewer to enter the interviewee"s „lived everyday world" (Kvale and Brinkmann, 2009:9). According to Morris (2015), semi-structured interviews are appropriate methods for sensitive topics. Since, my interview questions bordered on understanding interviewees everyday experiences of climate change and livelihood strategies which are nested within community social relations as a whole, the use of semi-structured interviews was deemed appropriate. Semi-structured interviews gave me the opportunity to establish a rapport with interviewees and gain access to rich personal data (Mellor, 2003). More importantly, the versatility of semi-structured interviews made it possible for me to

probe, seek to clarify responses, and examine complexity in responses (Creswell, 2003; Yin, 2013).

In Bagri, 64 semi-structured interviews were conducted with older, middle-aged and young men and women from a wide variety of income brackets and ethnic and occupational backgrounds. Key interviewees included the chief (*Naa*), earth priest (*Tingansob*), queen mother (leader of women), sectional/group leaders, and household heads. Interviewees were purposely selected based on their knowledge of community socio-economic life and their engagement in decision making. Ordinary men and women were also purposely selected to complement the perspectives of village leaders. In order to establish a rapport and reduce anxiety or fear, interviews were conducted at the convenience of interviewees, often within their compounds or immediate surroundings, and often under tree shade and in serene environments away from the presence of other people.

I started interviews by introducing myself, explaining the purpose of my stay in the village, asking permission for audio recording and assuring the confidentiality of the conversation. Audio recording was found to inhibit informants‟ responses during interviews (Dunn, 2010, Creswell, 2003). However, by contrast, I found this approach to interviewing useful. It allowed the natural flow of conversations (which was not the case with taking continuous notes) and the observation of gestures and facial expressions of interviewees. This enabled me to alternate between different questions when appropriate. I started interviews with simple questions relating to respondent‟s demographics, household composition, and occupation. This strategy was useful in „breaking the ice‟ and for natural conversation to flow. Once interviewees settled into the interview process, questions about different aspects of their lives in relation to environmental change, power dynamics, access to resources, local livelihood strategies and social networks were introduced. Holstein and Gubrium (2003:4) argue that, „the rapport you create, the questions you ask, the way you ask them and the manner in which you respond to answers and probe, will to a large extent determine the quality of the interview and content‟. All interviews with villagers were done in the preferred local language of the interviewee, mainly the Dagara and Hausa languages. Albert, my research assistant, provided assistance in many of the interviews conducted in Dagara. This is because the Dagara dialect spoken in Bagri, differed from the one I speak, requiring some interpretation. Ibrahim, an educated young Hausa man provided interpretation when my respondent spoke Hausa.

The same strategy was used for selecting respondents from formal institutions such as officials of government and non-governmental organizations in districts and the wider region. Interviewees were purposely selected using the snow-balling method. They were mainly selected based on their capacities as policy makers and policy facilitators or because of their involvement in climate change adaptation projects in Bagri and across the districts and wider region. For example, the villagers provided me with the contact numbers of agricultural extension officers and NGO field staff working on adaptation projects in the village. I subsequently contacted these individuals to schedule interviews. The aim of the interviews was to elicit views on climate change impacts, adaptation policies and strategies, how interviewees collaborate with stakeholders, and the successes and failures of adaptation measures implemented in order to adapt to climate change in local communities and across the wider region

Interviews with government officials, donors and NGO staff were conducted in English. However, in contrast to respondents in Bagri, a few officials were uncomfortable with me audio recording the conversations. Thus, in such cases, I recorded the conversations in a field notebook. All interviews lasted between 45 and 90 minutes. I closed all interviews by asking interviewees to talk about anything else that might not have been raised during the

conversation but that they deemed important to the topic. Indeed, it was often at this point that interviewees opened up on many issues that I had not explored during the interview itself. In several instances, after interviews had ended, I took notes on informal conversations with interviewees relating to the subject matter. Moreover, my presence in the study village and region made it possible to return to interviewees to seek clarity on issues that were not well understood in earlier interview sessions.

1.5.3.3 Focus group discussion

The focus group method involves a small group of people discussing a topic or issue that is defined by the researcher (Cameron, 2010). I conducted a total 22 focus group discussions with between six and twelve participants in each group drawn from various social and economic groups within the village. I first started with focus groups of men across the various ethnic groupings within the village, and followed with groups of women and then occupational groupings. This approach was useful in opening up opportunities for women to participate in focus group discussions in patriarchal societies such as Bagri and elsewhere in SSA. Indeed, once women saw village leaders (who were often men) participate in discussions, they were more willing to participate. The ultimate aim was for me to understand groups‟ perspectives, everyday experiences and the concerns that confront them as a group, including climate change, rather than their concerns as individuals (Bryman, 2018; Howell, 2013). More importantly, I was interested in how individuals responded to each other‟s views and the joint construction of meanings of everyday life by groups. The discussions were facilitated by Albert, my research assistant, and with the help of a discussion guide. Albert is a native of Lawra Town and a worker at the Lawra District Assembly. Other discussion aids such as flip charts were used to facilitate the ranking and scoring of socio-economic issues within their village by participants as well as their perception of climate change. I only intervened in the discussions to give direction when necessary, for example, when discussions were heading off topic, or to redirect questions to reticent participants and avoid the dominance of the discussion by only a few participants. This strategy was important in two main ways. First, it allowed me ample time to observe the demeanor and facial expressions of participants and interactions between them in arguments and counter-arguments. Secondly, it made it possible for me to record and take notes on important issues raised by various groups. Finally, when participants scored issues, the explanations offered for assigning specific scores to various issues provided insights for comparison among groups. For example, many participants questioned responses to questions by their fellow participants, which opened up insightful debates and facilitated learning within groups.

1.5.3.4 Cross-sectional walk and informal conversation

Cross-sectional walks and informal conversations were invaluable in complementing data gathered from interviews and focus group discussions. The strategy entailed asking participants after interviews or discussions if they could walk me round the village or farms in order to show me evidence of some of the topics raised during interviews and discussions. Many were willing and actually walked me through the village to show me evidence of climate change and various adaptation projects and strategies that had been implemented in the village over the last three decades. For instance, many interviewees took me to their farms to show me the different adaptation strategies they were implementing on their farms. They showed me evidence of the levels of the various floods that occurred in the village, agricultural fields that were swallowed by floods, and sites of various adaptation projects that have been implemented in the village. Important sites include the banks of the Black Volta River, afforestation and irrigation site and community boundaries. Importantly, it was during these walks that several issues were raised in informal conversations that I had not explored during interviews and discussions. Moreover, cross-sectional walks enabled me to take

photographs on various issues which I used to convey important case characteristics in all three papers. I took notes of emerging issues in my field notebook.

1.5.3.5. Household questionnaire survey

According to McGuirk and O'Neill (2010:191), questionnaires are useful for gathering original data about people, their behaviour, experiences and social interactions, attitudes and opinions and awareness of events. Accordingly, I used the questionnaire survey method toward the end of the empirical fieldwork to supplement data obtained from semi-structured interviews, focus group discussions and observations in order to better understand emerging themes and information obtained from qualitative research methods in the questionnaire. The questionnaire combined closed and open ended questions that related to the broad research questions of the dissertation. It also enabled a critical examination and understanding of relevant processes, patterns and relationships. As opposed to open ended questions, fixed-answer questions required a yes or no responses or a score on a scale of 1 to 5. They focused mainly on household socio-economic composition (age, sex, wealth, occupation), perceptions of climate change over the last 30 years and access to formal or informal social networks. The fixed-answer questions also included short comments from interviewees that were aimed at capturing a snap-shot of household perceptions and experiences of climate change as well as livelihood strategies implemented in the face of these changes. The questionnaire was administered in general to household heads or adult members of the household that had adequate knowledge of household assets and livelihood strategies. A household was defined as „a person or a group of persons, who live together in the same house or compound, share the same house-keeping arrangements and recognize one person as the head of household" (Ghana Statistical Service, 2010: 26). The survey covered 127 of 198 total households in Bagri. The sampling procedure for the household survey was designed to provide a representative sample of households across the various socio-economic groupings in Bagri (see Figure I-1 and Table I-1).

1.5.4 Secondary document sources, analysis and presentation

Secondary data documents were also key in my collection process. These documents were obtained from government officials and the project staff of NGOs. After interviews, I usually asked them to provide me with relevant documents related to issues we had discussed during interviews. I must emphasize here that many officials were reluctant to make these documents available. The few documents that were made available to me include the Ghana climate change adaptation policy and strategy, medium-term development plans of the various district and municipal assemblies covered in this study, minutes of meetings of climate change adaptation platforms, as well as rainfall and temperature data from the Ghana Meteorological Agency weather station at Babile. In this dissertation, documents were predominantly analyzed as sources of information that describe the policies and facts that underline them. For example, I analyzed climate data that had been compiled at the Babile weather station to understand the pattern of climate change. This was then used to draw climate graphs to support the arguments of all three papers in this dissertation. The secondary documents also complemented and triangulated information obtained from interviews. As noted by Karppinen and Moe (2012), documents can also be a subject of study when they are analyzed for value-laden assumptions that influence behind policy-making. Therefore, my use of secondary documents should be viewed as in this light.

Table I-2: Methods, thematic areas, temporal span and quantity

Methods	Quantity	Thematic area	Time span	Target sample
Semi-structured interview	Households 64 (Men-40, women-24)	Environmental and socio-economic change Livelihood assets and vulnerability Climate services and adaptation strategies Collective activities and knowledge systems	30 years back	Sampled across gender, age groups and ethnicity
	Formal institutions 14 (NGOs-6, State-8)	Role of external institutions		
		Climate change interventions and barriers	Past & present	
Focus group discussion	22 (Men -10, Women-8; Men &Women-4)	Socio-economic & biophysical change Community adaptive capacity Community Knowledge systems Role of external institutions Access to climate services	30 years back & present	Sampled across gender, age groups and ethnicity
Survey	127 households out of 198	Household profile (socio-economic assets) Perceptions and access to climate services Household adaptation strategies Migration history and links with external agencies		Household heads
Informal conversation	Presence in Bagri	Across various themes	30 years back & present	Across gender, age groups and ethnicity
Participant observation	Presence in Bagri	Daily activities, farming practices, wealth, assets owned, power dynamics	Present	Across gender, age groups and ethnicity

1.5.5 Transcription, coding and data analysis

In general, transcription and analysis of data started at a very early stage of the fieldwork. The strategy was to transcribe all audio recorded interviews in a particular day. Incomplete audios recordings were transcribed during the weekends or on days that I had no interviews to conduct. This strategy was helpful in that it allowed me to identify questions that were not properly answered, enabling me to then seek further clarifications in subsequent interviews. I analyzed qualitative data using the inductive method which involves the identification of patterns, themes and categories present in the data (Patton, 2002). As a first step, I read individual transcripts, elaborated on them, and added remarks, and questions marks using different colour marks where necessary. The second step involved developing theme summaries that corresponded to the research questions. Common themes developed included perception of climate change, household assets, access to resources and livelihood diversification strategies. Following this step, I categorized the data (e.g. socio-economic status, ethnicity, gender) based on all qualitative data sources in order to identify convergence and divergence among my respondents. Using content analysis, I then interpreted the emerging themes and categories by giving explanations. The final step was to bring the whole analysis together and provide answers to the three main overarching research questions that guided this dissertation. In general, throughout the write-up of the three research papers, the analysis of the qualitative data was iterative and involved recalling the physical settings of the village, respondents‟ feelings, emotions and emergent debates on topical issues. Listening to recorded interviews and reviewing photographs of important events that took place during the fieldwork was equally important in my analysis of qualitative data. The household questionnaire data was coded and input into the Statistical Package for Social Science (SPSS) software package version 20. Cross tabulation and analysis of different variables (ethnicity, age, diversification strategies) and interpretation of frequencies was carried out and processed into tables, graphs and percentages.

1.6. Methodological reflections: my position in the field

The role of the researcher as the primary data collection agent has necessitated a long standing debates in human geography concerning the identification of personal values, assumptions and biases (e.g. Massey, 1991; Ley, 2003). Seeing as I am the one who framed the research problem, designed the research instruments and methods, and collected data, my world view and personal values influenced how I conducted the research and the findings. Turner (2010), for example, acknowledges that researchers, their assistants and translators have their own positionality that influences research findings. I take this opportunity to reflect on my position from the position of an insider-outsider.

In the view of Locke et al (1987), the investigator‟s contribution to the research setting can be useful and positive rather than detrimental. In general, being an insider, i.e. a native who is living and working as a researcher in the study area, I considered myself an insider within the district and regional context. For example, I have had previous working contacts and/or attended the same University (undergraduate) as a number of my respondents working in various state institutions and non-governmental organizations at both the district and regional levels. This position had a positive impact on the field work. Many respondents were willing to provide me information and materials and allowed access to various stakeholders working on climate change. For example, Mr. Enoch Bilguo, a worker at the Lawra District Assembly and a former student of mine, offered me a desk in his office and introduced me to key officials. This fostered trust in diverse ways as many officials were willing to provide me information and access to important documents and openly talk to me. Sitting at the office in Lawra town where there is electricity made it possible for me to work on my computer during days that I was not working in Bagri. This, in particular, was important for transcription and

analysis of field notes. In general, my presence at the Assembly and the opportunity for informal conversations created an atmosphere of familiarity with officials. This was also important in my selection of my research assistant, Albert a native of Lawra who worked at the District Assembly.

In general, I considered myself and Albert as outsiders during the fieldwork in Bagri. As the Dagara tradition demands, I first called on the chief at his palace and offered him a bottle of Schnapp and Kola. He welcomed Albert and I and quickly summoned his elders for a meeting. In the meeting, Albert, who is known by the villagers introduced me to the chief and his elders. After listening to Albert, the chief and his elders were very hospitable and welcomed me with open arms. The chief assured me of their support and further asked his elders to circulate information of my presence and tasked all ethnic/sectional heads to support me in carrying out my work. Indeed, the presence of Albert, his status at the Lawra District Assembly, and having external family relations in the village, made our acceptance by the villagers possible.

After winning the support of the village, the next hurdle was to win the trust of ordinary men and women in the village. This was initially challenging as many villagers believed that I was a development worker. In particular, many young men approached me to narrate their personal challenges and asked if I could support them with my project interventions. I deflated this expectation with the help of Albert by constantly explaining that my work in the village was solely for research, and that I was there to write their stories and experiences of climate change in „books" for individuals and organizations who have the capacity to support them to do so. This explanation, together with my constant presence and participation in village social activities helped fostered trust and diffused the idea that I was a development worker.

In addition to the access I was able to gain, I strongly believe that my status as a male researcher conducting research in a male dominated society such as Bagri affected the research process in several ways. In qualitative research, the role of the researcher as the primary data collection agent necessitates the identification of personal values, assumptions and biases at the outset of the study (Creswell, 2009; Baxter, 2010; Bradshaw and Stratford, 2010). For example, I more easily associated with men than women, and I therefore had more interactions with men than women. Women in general were not forthcoming with information. To avoid this bias, I asked about or identified women leaders such as the Queen mother of Bagri who were more open because of their familiarity with development workers to organize other women for group discussions. I found this strategy to be fruitful as, when women organized with one another and came together to speak, such discussions were lively and open. However, a side effect of this strategy was the tendency of such women in leading roles to dominate the discussion. To avoid this, in discussions among women, Albert and I sometimes interjected in such discussions to give directions and to open up the conversation to include reticent participants.

Finally, both Albert and I can be considered as „outsiders" while we were equally „insiders" in several ways. We both have a good knowledge and understanding of the socio-cultural and environment conditions of the people of northern Ghana in general. This might have made us overlook certain interesting events during the fieldwork.

Chapter II

Climate change extremes and barriers to successful adaptation outcomes: disentangling a paradox in the semi-arid savanna zone of northern Ghana

This is an accepted manuscript of the following article: Dapilah, F and Nielsen, JØ (2019): Climate change extremes and barriers to successful adaptation outcomes: disentangling a paradox in the semi-arid savanna zone of northern Ghana. *Ambio*. Final version is available DOI/10.1007/s13280-019-01275-x

Overflown banks of the Black Volta River in Bagri

Women of Bagri smoking fish to sell in markets

Abstract

The literature on barriers to climate change adaptation has largely focused on non-climatic barriers with less insight on climate-induced barriers. Responding to this lacuna, this paper examines the connections between climate change and agricultural adaptation strategies of smallholder farmers in northern Ghana. Results from the qualitative fieldwork show that, climatic changes have been accompannied by increasing climate change extremes (CCEs) over the last three decades. To adapt, smallholder farmers use improved crop varieties and other support strategies. Paradoxically, however, CCEs undermined these strategies in several instances, causing crop yields to fall short of their actual potential leading to financial indebtedness. The results therefore, showcase that, surmounting non-climatic barriers to the uptake of agricultural adaptation strategies is a necessary but not sufficient condition to achieving successful outcomes, as new barriers in the adaptation process beyond uptake are constantly emerging with CCEs being one example.

1 Introduction

Climate change impacts, related losses and damages are increasing (IPCC, 2018; World Economic Forum, 2019). When these consequences are coupled with increasing global greenhouse gas emission, urban expansion and unsustainable consumption (IPCC, 2018; Preston et al, 2013), the pursuit of adaptation to avoid adverse outcomes is a present necessity and a significant future challenge (Adger et al., 2009; Ernst et al., 2019; Smit and Wandel, 2006).

Adaptation is a continuous process of adjusting to changes in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2012; Smit and Wandel, 2006). Within this process, the literature distinguishes between incremental and transformational adaptation (Kates et al., 2012; Nelson et al., 2007). Incremental adaptation to climate change refers to the extension or adjustments of actions and behaviors, or doing slightly more of what is already being done to reduce losses (Kates et al., 2012; Park et al., 2012). In contrast, transformational adaptation refers to adaptation options that are new to a particular locality, adopted at a much larger scale, and results in a shift in the local resource system (Adger et al., 2011; Kates et al., 2012; Nelson et al., 2007). This paper focuses on incremental agricultural adaptation strategies of households in Bagri, northern Ghana. It does so while also understanding these as nested in collective adaptation strategies of the community as whole.

The scholarship on climate change adaptation differentiates between adaptation and successful adaptation (Adger et al., 2005; Barnett et al., 2015). For instance, Adger et al (2005:80) argue that "defining successful adaptation in terms of meeting stated objectives is inadequate for two main reasons: firstly, whilst an action may be successful in terms of one stated objective, it may impose externalities at other spatial and temporal scales. Secondly, what appears successful in the short term turns out to be less successful in the longer term".
Notwithstanding this conundrum, a number of recent studies argue that successful adaptation is more about the sustainability of the processes that produce equity, fairness, effectiveness and efficiency, than measuring outcomes at any given point in time (Hurlimann et al., 2014; Barnett et al, 2015; Adger et al, 2005). Defining and attaining successful adaptation therefore remains a challenge because, stakeholders have to navigate multiple barriers in order to implement successful adaptation strategies. For example, although adaptation efforts have increased, particularly in the the last decade, many of these efforts have struggled to overcome barriers and to implement tangible adaptation actions (Lesnikowski et al., 2013; Mertz et al., 2009).
Huang et al (2011:185) defined barriers as "any condition that makes it difficult to achieve progress towards adaptation". As such, barriers to adaptation are viewed as obstacles that can be overcomed with concerted efforts, creative managements, change of thinking, prioritization, and related shifts in resources, land uses and institutions (Adger et al., 2009; Dow et al, 2013; Moser and Ekstrom, 2010). In the last two decades, the importance of identifying and overcoming barriers to climate change adaptation has increased rapidly with an urgent attention being paid to developing countries due to their high vulnerability and consequently low adaptive capacity (Adger et al., 2009; Barnett et al., 2015; Biesbroek et al., 2013; Eisenack et al., 2014; Nielsen et al., 2012). The reasons for the increasing attention to adaptation barriers are manifold. First, the threat posed by climatic changes that will occur or are currently ocurring raises questions regarding whether societies have the capacity to adapt (Adger et al., 2009; IPCC, 2014). Second, there is sufficient agreement that, with current climatic changes, climatic barriers in the adaptation process will always emerge (Adger et al., 2009; Klein et al., 2014). Finally, there is a need to understand in detail and define specific

barriers and the contexts in which they are identified (Moser and Ekstrom 2010; McNeeley 2012).
In this respect, several barriers to adaptation have been adduced in the scholarly literature, including but not limited to, policy and instituitional coordination, conflicting interests of stakeholders, disconnect between producers and users of climate information and socio-economic factors (Amundsen et al., 2010; Biesbroek et al., 2013; Eisenack et al., 2014; Moser and Ekstrom, 2010). However, much less research has focused on the direct and indirect connection between climate-induced barriers and already implemented adaptation strategies, particularly in developing countries (Schlenker and Lobell, 2014; Shackleton et al., 2015). Indeed, many authors (e.g. Burch, 2010; Moser and Ekstrom, 2010) suggest that climate change can make some barriers more tenacious, heighten other barriers and/or set into motion new barriers even after an adapatation strategy has been implemented.

Consequently, understanding climate change as a barrier, and in particular climate change extremes (CCEs) as these often challenge incremental adaptation strategies (Deutsch et al., 2018; Kates et al., 2012) in the context of Sub-Sahara Africa (SSA) is particularly urgent for four main reasons. First, vulnerability to climate change is linked to a high reliance on climate sensitive economic activities such as agriculture and it is in this sector we see many incremental adaptation strategies as moving people out of agriculture very challenging (Connolly-Boutin and Smit, 2016; Niang et al., 2014; Ziervogel, 2019). Second, the region is expected to warm faster than the global average and likely to exceed 2˚C by the last two decades of this century (IPCC, 2014), which is likely to affect agricultural productivity without immediate and potentially transformational adaptation measures (Lobell et al., 2011; Roudier et al., 2011). Third, this will very likely increase the risk for CCEs (IPCC, 2014, IPCC, 2018) which, as we will show in this paper, might then increasingly become a barrier to the succesful outcomes of implemented adaptation strategies. Fourth, there is the problem of there being an inadequate number of weather stations (IPCC, 2014; Lennard et al., 2018) and good quantitative historical climate data (Seneviratne et al., 2016; Singh et al., 2018; Sylla et al., 2016) resulting in limited access to climate information and an understanding of CCEs (Amegnaglo et al., 2017; Boyd et al., 2013).

Nevertheless, as Shackleton et al (2015) argue, much of the existing literature on barriers to climate change adaptation in Africa reflects the already known and easily detected non-climatic barriers, i.e., financial, socio-cultural, informational and governance barriers. More knowledge is therefore, needed on the intertwinement of CCEs, such as drought and/or dry spells, windstorms, heavy rainfall and floods and agricultural strategies implemented by smallholder farmers to adapt to climate change. This will be the focus of this paper. Specifically, it is argued here that, if adaptation is a process (IPCC, 2007; Smit and Wandel, 2006) it is necessary to understand the different barriers that emanate from within the adaptation process i.e., from uptake through implementation and outcomes of adaptation strategies.

2 The study setting and methods

The study took place in Bagri, a small village in the Lawra district of the Upper West Region of Ghana. Bagri lies approximately on latitude 10˚43′ north and longitude 2˚53′ west and about 15km away from Lawra town (Figure II-1). The last census (2010) indicates that the village has 198 households with a total population of 1,040 (Male: 514; Female: 526) and consists of mainly the Dagara, Wangara, Hausa, Fulani and Waala ethnic groups (Ghana Statistical Service, 2012). The economy of the village is subsistence based with crop production being the dominant economic activity. Other economic activities such as livestock rearing, fishing, horticulture and trade make up key household livelihoods. The educational

level of the people is generally low. The village has only a basic school built by the Baptist Church in 2014.

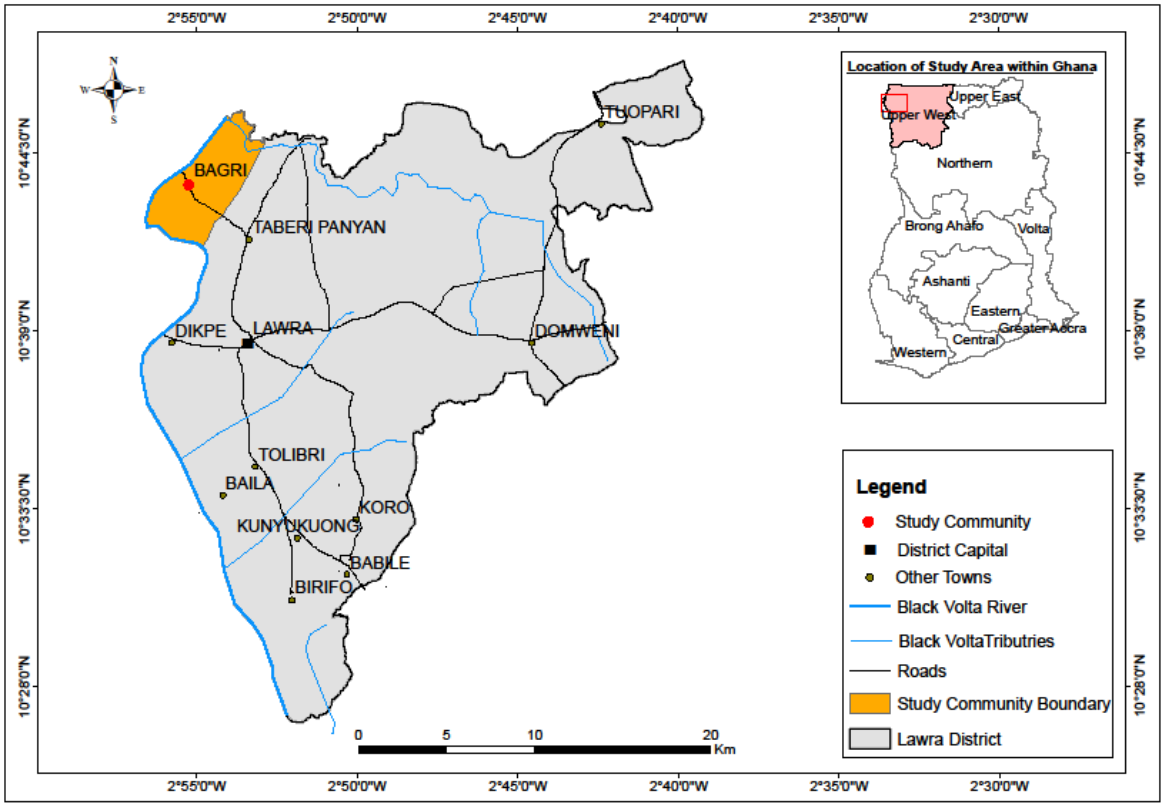

Figure II-1: The location of Bagri

Access to basic infrastructure to support economic activities is also highly inadequate. There is no electricity, agricultural storage facilities and equipment (e.g. tractors, silos) and irrigation facilities such as dams in the village. As a result, the people depend on private providers of agricultural services found outside of the village. Moreover, access to transport and communication services in Bagri are generally poor. The only available transport networks linking Bagri to other villages are foot and motorcycle paths that become impassable during the rainy season. For example, residents of Bagri are unable to travel to Zambo, a major trading center in Burkina Faso to buy or sell goods during the rainy season when the Black Volta River overflows its banks. Likewise, traders from Bagri are only able to trade at the Wa central market, the regional capital of the Upper west Region once a week due to lack of transport services.

In addition, despite the fact that the village has access to MTN and Vodafone mobile communication networks, the mobile networks are erratic and unstable coupled with interference/conflicts with other networks operating in Burkina Faso. Though, in the last decade, there have been considerable efforts by governments and donor organizations to provide electricity and irrigation facilities, the people of Bagri are yet to benefit from these projects as they have all stalled (e.g. UNDP irrigation project in Bagri).

No meteorological records exist for Bagri, but in the nearest town with a weather station, Babile, rainfall and temperature data have been collected since 1975. The data-sets indicate declining rainfall amounts and rising temperature trends over last three decades (Figure II-2 and Figure II-3).

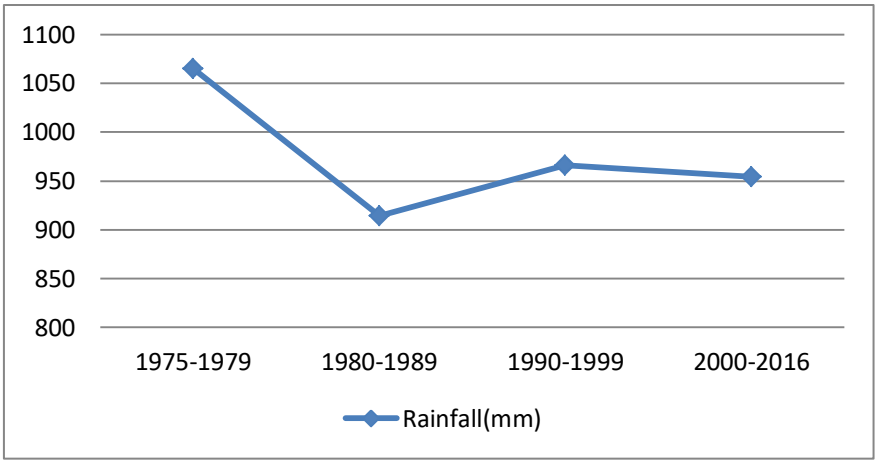

Figure II-2 : Average rainfall for Babile (1975-2016)

Source: Adapted from GMet weather station, Babile

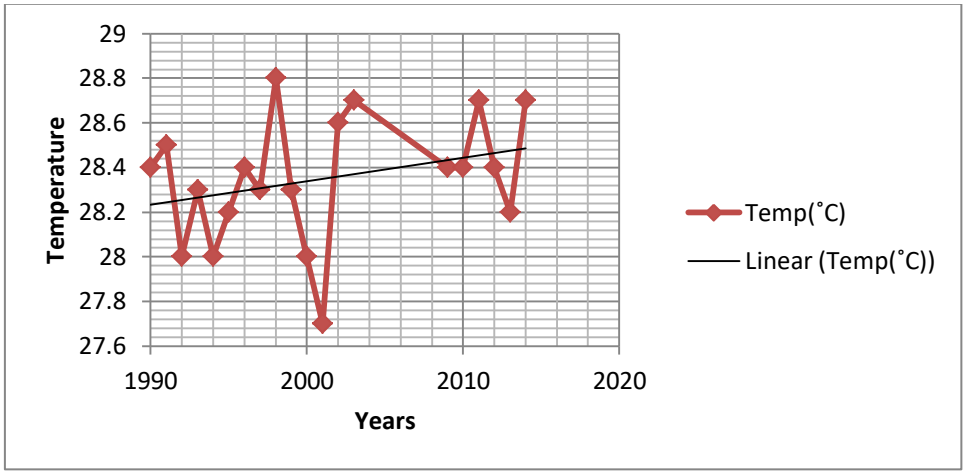

Figure II-3 : Average Temperatures for Babile (1990-2014)

Source**:** Adapted from GMet weather station, Babile

The empirical data for this study was obtained between February and July, 2017 using four main methods: semi-structured interviews, focus group discussions, survey and ethnographic participant observation with the first author living in the village. Semi-structured interviews (64) were conducted with older, middle-age and young men and women from a wide variety of ethnic, occupational and wealth groups. This allowed an in-depth understanding of the different perception of climate, adaptation strategies and barriers by the elderly, the young, and the different genders. Interviews at the village level were triangulated with key expert interviews (14) with officials from government agencies and non-governmental organizations working in the community. The aim of this was to elicit their views on climate change impacts, adaptation strategies and interventions that had been implemented in order to build community adaptive capacities to climate change**.**

Following the basic insight gained from semi-structured interviews, focus group interviews (24) were conducted with men, women, and some involving both men and women, in order to achieve broader corroboration of the information obtained from semi-structured interviews. This was then followed-up by an assessment of the inherent strength and weakness of the different adaptation strategies known to participants using participatory research approaches such as ranking and scoring. All interviews and discussions were done in Dagaare and Hausa

(with the help of an interpreter) or in English when the interviewee/s was/were sufficiently fluent.

A total of 127 (out of 198 households) questionnaire was administered to household heads. These were stratified to cover the socio-economic groupings in the community. The survey was semi-structure and captured (1) household socio-economic characteristics, (2) the perception of climate change and impacts over the last 30 years, and (3) the dominant adaptation strategies and the barriers associated with their implementation. Data from questionnaire surveys were coded and inputted into SPSS version 20 and cross tabulation and analysis of different variables and interpretation of frequencies were done and processed into tables, graphs and percentages. Content analyses of qualitative data were done which allowed patterns and themes in interviews and discussions to be derived and interpreted.

3 Results

3.1 Perception of climate change

Generally, respondents perceived a change in climate over the last 30 years (Table II-1). All household heads in the survey perceived a change in the annual dry and rainy season precipitation over the period. About 86.6 % of respondents believed that annual precipitation had decreased. With regards to dry spells and intensity of rainfall events, 91.3% and 69.2% perceived that both precipitation parameters have increased over the period respectively. Majority (74%) of respondents perceived that floods and inundation of fields had occurred with increasing frequency over the time period. Concerning temperatures, 88.1% and 69.2% of household heads suggested that dry season and rainy season temperatures had increased respectively. Finally, 87.4% and 43.4% of respondents suggested that the intensity of dry season and wet season winds had increased respectively.

Table II-1: Perception of climate change and variability over the past 30 years (N=127)

Climate variables		Increased (%)	No change (%)	Decreased (%)	Can´t Tell (%)
	Annual	7.8	5.5	86.6	0.0
	Rainy season	5.5	0.0	80.3	7.8
	Dry season	0.0	93.7	1.5	4.7
	Dry spells, rainy season	91.3	6.2	2.3	0.0
	Intensity of rainfall events	69.2	15.7	11.8	3.1
Precipitation	Inundation of fields	58.2	18.1	33.8	0.0
	Dry season temperatures	88.1	0.0	4.7	7.0
Temperatures	Rainy season temperatures	69.2	10.2	4.7	15.7
	Length of cold period	14.1	3.9	74.0	7.8
	Length of hot periods	88.1	0.0	8.6	3.1
	Intensity, dry season	87.4	6.2	7.0	0.0
Winds	Intensity, rainy season	43.3	16.2	25.9	14.1

Source: Survey, 2017

In addition, there was general corroboration among the villagers of Bagri, field staff of NGOs and government actors at the Lawra district Assembly that the rainfall has reduced in length/duration. Currently, low annual rainfall amounts were also perceived and the rainfall pattern was perceived more erratic now than some three decades ago. Respondents perceived these changes have impacted negatively on rain-fed agriculture in the village. For example, respondents mentioned that in the 1970s and 80s, the months of May and June usually marked the harvesting of crops such as cowpea. However, currently as cowpea is harvested in July or August. This situation was attributed to a delay in the onset of rains and a shift in the seasonal

calendar. As observed during the fieldwork and confirmed by respondents, the early rains so vital to mark the beginning of sowing crops often had a „false start" making it difficult to know when to sow. The disappearance of flora and fauna, and growing problems with pests and diseases were also mentioned as a consequence of climate change by the villagers, all of which has made rain-fed agriculture difficult and requires some form of adaptation.

Above all, accompanying climatic changes (short duration, erratic patterns, declining rainfall amount, rising temperatures) are observed increasing frequency and severity of CCEs such as drought and dry spell, windstorms, heavy rainfall and floods. These events according to respondents were unusual and mentioned by respondents to be „extreme" because they were highly unpredictable and destructive. The villagers described drought situations as when there is lack of rains during the rainy season coupled with excessive temperatures, insufficient water and moisture in the soil to support the growth of crops. The persistency of inadequate moisture in the soil to support the growth of crops define drought as a climate extreme event. During drought periods, the upper part of the soil becomes hard with loose soil particles produced dust. Dry spells therefore shared all the characteristics of drought, except that they had a short duration of about two weeks.

Flood and heavy rainfall events were generally described as periods of intense rainfall. Key features of flood events are inundation of fields and over flowing of rivers and ponds in the village. Heavy rainfall events are characterized by prolonged and continuous rainfall for more than two days or the intensity of rainfall together with strong winds usually lasting about one to two hours. These caused excess water in the soil/water-logging or flash floods. Windstorms were described to be associated with intense rainfall events, especially when clouds gather and the rains are about to fall. Windstorms pulled-down roofs of buildings, trees and crops. The villagers have adjusted to the climate changes related to the short duration of the rainy season and low rainfall amounts by using a number of incremental adaptation strategies including improved crop varieties, fertilizers and pesticides. However, the worry of respondents was that, the incremental adaptation strategies they have implemented to adapt to climate change were insufficient or unsuccessful in adapting to the emerging CCEs experienced in the village.

3.2 Climate change extremes and barriers to successful adaptation

All households in the survey mentioned that they had adapted their agricultural strategies to negate the impact of the climate change. One strategy involved using improved crop varieties (Figure II- 4).

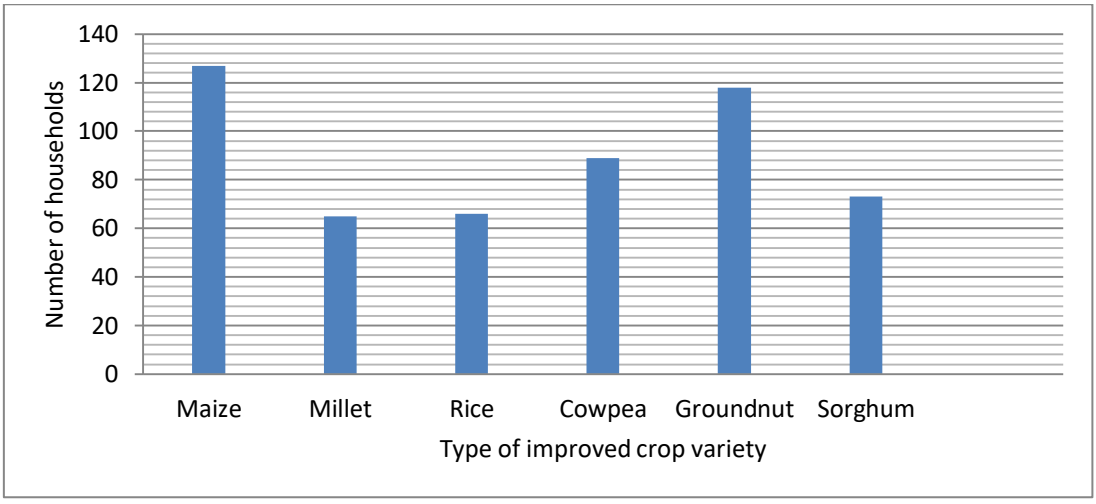

Figure II-4: Type of Improved crop variety cultivated by number of households (N=127)
Source: Survey, 2017

Improved crop varieties were introduced through donor funded projects implemented by local non-governmental organizations (NGOs) and facilitated by agricultural extension officers in the village. Although, their introduction began in the 1980s, their uptake and implementation as a climate change adaptation strategy has increased since the beginning of the 2000s. The oft mentioned advantages of improved crop varieties of maize, groundnut and cowpea are: drought tolerant, short duration to maturity (often between 60-90 days), and high yield (quality and quantity). By contrast, non-improved/traditional crop varieties produced less yields with smaller grain-size, long duration to maturity (about 4 months) and high mortality rate during climate change.

The qualities of the improved crops were said to have been proven and tested by Association of Church-Based Development Projects (ACDEP), a non-governmental organization in 2014 on agricultural demonstration fields established in Bagri as part of the diffusion process of improved crops varieties in Bagri. Agricultural extension officer, Mr. Constantine Faar, mentioned in an interview that: "Now, farmers have abandoned the non-improved (traditional) crop varieties as farmers observed on the demonstration farm that, their own variety had a high mortality rate and also less grain yield compared to the improved crops". This was a point reiterated by many farmers in interviews and informal conversations. Nonetheless, despite the ability of improved crops to withstand variability in climate, extreme climate events undermined their use as an adaptation strategy to climate change (Figure II-5).

A number of factors informed the ranking of crop variations by their sensitivity. First is the connection between the timing of crop cultivation and that of the occurrence of CCEs. Early crops such as cowpea and maize were more vulnerable to drought, dry spells, heavy rainfall and extreme temperatures often associated with the „false start" of the rains at the beginning of the season. These events hindered the planning of agricultural activities, which eventually affected seed germination and viability and in some cases, caused seed rot and death. Similarly, drought, dry spells and heavy rainfall occurring mid-season stalled crop pollination and flowering processes, caused water-logging and made crops wither. Maize and sorghum were examples of crops that were severely affected during the mid-season. Late crops such as groundnut and millet were also affected by CCEs occurring towards the end of the wet season. Drought usually associated with early cessation of rains towards the end of the rainy season made the harvesting of groundnut difficult (because of hard soils) causing losses in harvest as groundnuts yields remained buried in the soil in many instances.

Moreover, a second factor that informed the variation in ranking of the perceived susceptibility of different crop types to CCEs by households was the physiology of crops. For example, maize, millet and sorghum were ranked as highly susceptible to windstorms because such crops were easily pulled-down as they grow thin and tall and, at the same time, carry weight during their grain filling stages. The type of land that crops were cultivated on combined with the water requirements of the crops was a third factor that informed the ranking of crop varieties to CCEs. Groundnuts and millet required less water and rains and, as such, were ranked as not particularly susceptibility to drought in comparison to rice. Rice was ranked as more prone to floods because it was usually cultivated in valleys and marshy fields. The main staple crop of the village, maize, was ranked by many respondents to be very sensitive to many of the different types of CCEs (Figure II-5). While the improved seed type produced maize that was better adapted to short rainy seasons with less rains, it was still susceptible to multiple CCEs. This is because, as mentioned by interviewees, the maize variety required equal amount of both rainfall and sunshine at different stages of its life-cycle

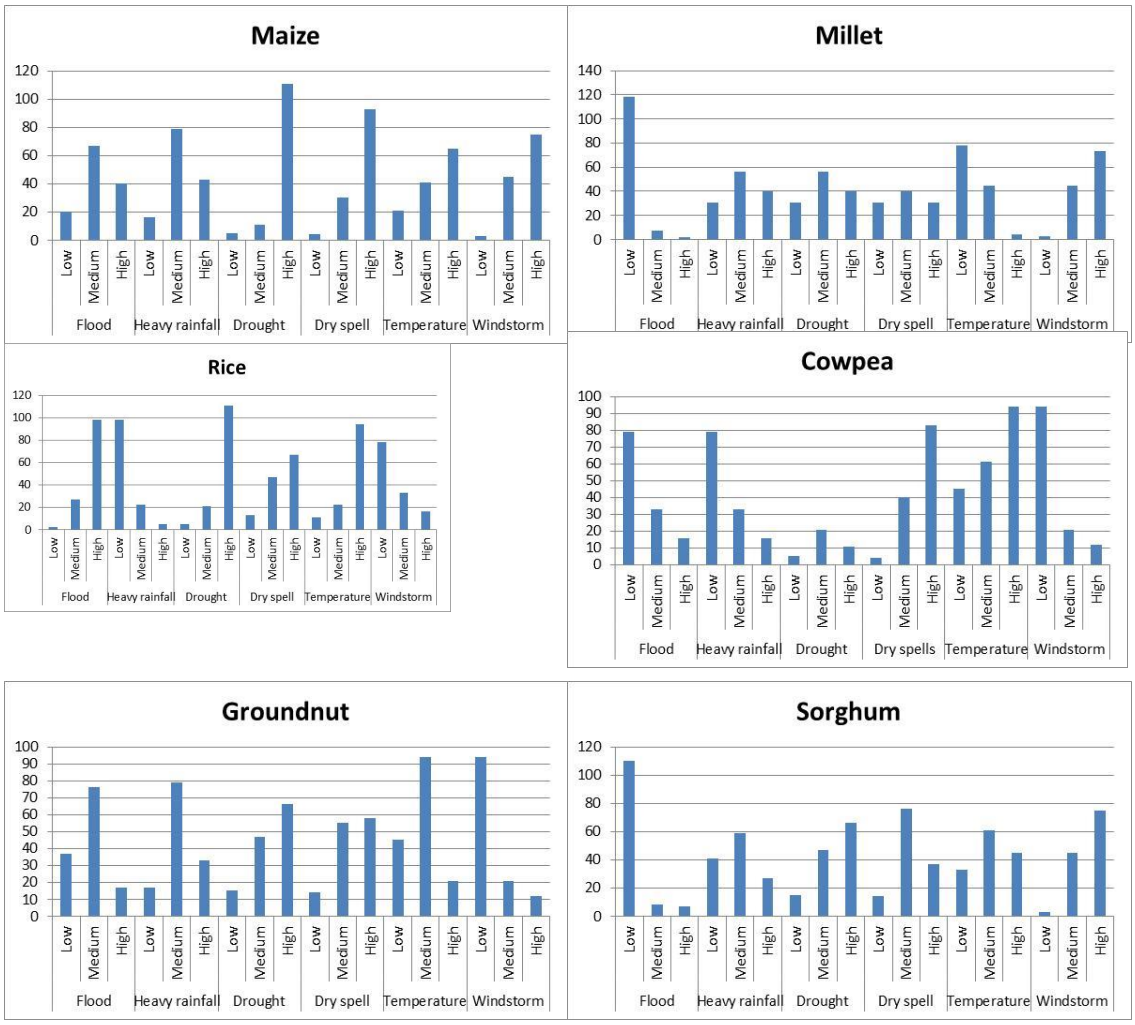

Figure II-5: Household perceived sensitivity of crops to climate change extremes (N=127)

Source: Survey, 2017.

These climatic conditions required for the cultivation of maize has become rare in the village within the last three decades. The emergence of new maize diseases and pest perceived to have been caused by excessive temperatures during drought. For example, fall army worms in the years 2016 and 2017 caused the death of maize crops before they reached maturity. Likewise, frequent heavy rainfall and floods experienced since the early 2000s swallowed and/or caused water-logging of maize crops cultivated on marshy fields along the Black Volta River all leading to low agricultural yields (Plate II-1).

Impact of drought and pests on *Padituya* bean crop variety on demonstration farm in Bagri

Inundation of maize crops cultivated along the banks of the Black Volta River in September, 2018

Plate II-1: Negative impact of CCE on improved crop varieties in Bagri
Source: Authors, 2017

The second type of agricultural adaptation strategy implemented in the village was the use of fertilizers and pesticides. About 66.9% of households in the questionnaire survey mentioned that they used both fertilizers and pesticides as complementary adaptation strategies in the production of improved crop varieties. Fertilizers and pesticides together with improved crop varieties were introduced by agricultural extension officers and development organizations in the late 1990s and early 2000s either through subsidies or as gifts. They were generally seen as way to adapt to climate change. Indeed, all our informants indicated that fertilizer and pesticide were necessary, as without them, the cultivation of improved crop varieties was impossible.

As such, the use of improved crops, fertilizer and pesticide coevolved as adaptation strategies. Imoro, a 45 year old Hausa man emphasized the increasing importance of fertilizers in the village stating that "presently farming is fertilizer and fertilizer is farming". The use of fertilizer and pesticide facilitated the early crop growth needed to meet the short rainfall season. It also prevented crop pests and diseases. Indeed, good yields had been experienced in the village. For example, respondents mentioned that an acre of maize plot cultivated with fertilizers and pesticides could produce about six bags of maize (80kg per bag) compared to only two bags in fields were no fertilizer and pesticides were applied.

Nevertheless, over the past two decades, this strategy has become increasingly challenged by climate change and the accompanying extreme events. As respondents noted, climatic factors are essential determinants of successful fertilizer use, as fertilizer can only be applied when soils are wet. Wet soils therefore facilitated the sipping and absorption of fertilizer nutrients by crops. However, the lack of a „reasonable" rainfall, that is, an evenly spread rainfall in both quantity and duration remained elusive and thus affected the use of fertilizers. As a result, since the early 2000s, drought and/or dry spells have become increasingly problematic for this adaptation strategy.

In addition, the increasing experience of heavy rainfall was similarly problematic. Respondents recalled several instances in which fertilizer had been applied to crops only to be washed away a few hours later. Besides, when there was drought and/or dry spells during the season, fertilizers could not be used on crops. As a female farmer Kuukyi outlined: "sometimes when we apply fertilizer on crops, it is washed-off by heavy rains. Other times too, when the crops need fertilizer, the rains come to a standstill so we are not able to use

them". In a similar vein, another female farmer Hajia mentioned that: "last year we could only apply *compound fertilizer* but not the *sulphate of Amonia* because of the dry spells we experienced, so the crops did not do well". Many respondents mentioned that, the improved crop varieties that they cultivated did not do well, i.e. a shortfall in expected outputs of six bags per acre (80kg per bag) to about two bags per acre of cultivated land in 2010, for example. This is mainly because, in several instances, they were unable to use fertilizer on crops in the right quantities and at the right time, as explained above.

The improved crops were also mentioned as being heavily affected by crops pests and diseases. The subject was laden with diverse views with a lack of clear evidence showing that improved crops were more susceptible to pests and diseases than non-improved varieties. However, a common point that emerged during interviews and discussions was that in general, there has been an upsurge in the emergence of alien crop pests and diseases in the village since the early 2000s.

This was perceived by respondents to be a result of rising temperatures. Different types of pests and diseases were mentioned as affecting different crops in the village. For example, pod borer pests, nematodes and fall army worms affected maize and cowpea whereas leaf blight and leaf curl were also associated with sorghum, groundnuts, maize and millet. To adapt to this, pesticides were used to control pests on improved crop varieties. The use of pesticides required consistent and good knowledge of rainfall. As shown, this is not happening. In several instances applied pesticides are often washed-off improved crops by heavy rain events. Thus, the timing of their use throughout the life-cycle of crops is essential for successful adaptation.

The third strategy consisted of minimal tillage and weeding practices. Minimal tillage practices were mentioned as necessary as they negated the impact of droughts on crops. Minimal tillage therefore ensured the addition of layers of soil to help preserve moisture, enabled the roots of plants to stand firm in the ground, resisted erosion caused by heavy rainfall, and prevented crops from being pulled down by windstorms. Weeding also prevented competition for nutrients between crops and weeds.

Although, minimal tillage and weeding practices were not unique to the cultivation of improved crop varieties, the point often emphasized by our respondents was that, the timing of these activities was more important for their cultivation in the case of improved crops. This is mainly because, improved crops required strict minimal tillage and weeding regimes, with at least two different minimal tilling and weeding practices done at optimum times throughout the life-cycle of crops. The first minimal tillage and weeding were often undertaken between the third and fourth week after sowed seeds have germinated and turned into young crops. This was then subsequently followed-up by a second set of minimal tillage and weeding when crops were about to reach their flowering and pollination stages (in the sixth and seventh weeks).

Drought prevented tillage and weeding practices at the „right time" within the crop life-cycle, as the ground became too hard for such activities to be undertaken. This led to weeds outcompeting and „killing" crops and as opposed to crops, they could survive under drought conditions, a point often mentioned by respondents. Likewise, heavy rainfall, usually occurring between July and August, caused water logging which constrained tilling and weeding practices. An interviewee named Der, recounted his experience: "I can recall that in the month of August 2014, we had constant rainfall lasting almost the whole day for about a week, which affected cowpea yields in the whole village. For example, I could not weed my crops for the second time last year because there was too much water in the soil which made it

sticky and difficult". Thus, for many respondents, minimal tillage and weeding practices were not carried out at specified times, a situation that resulted in weeds outcompeting crops for nutrients and lead to undesirable outcomes in the form of crop failures and low yields.

The fourth strategy implemented in the village in order to negate the impact of poor rainfall on crops has been the increasing cultivation of valleys and marshy fields. These fields were traditionally used for rice farming. Now, however, these fields are used for the cultivation of improved crop varieties such as maize and cowpea. Adopted since the early 2000s, this strategy has been a clear response to climatic changes experienced in the village, especially drought and dry spells. The main reason for this was that, such fields were perceived as fertile and better at holding moisture for long periods, even in severe drought conditions. Indeed, compared to the 1990s, valleys and marshy fields along the banks of the Black Volta River are presently intensively cultivated all year round.

Nevertheless, the perceived advantages of marshy fields‟ water/moisture holding abilities during drought and their fertility compared to other arable fields, crops grown there were extremely vulnerable to floods. Respondents mentioned that in the years 2000, 2004, 2010 and 2014 floods swallowed crops grown on marshy fields along the banks of the Black Volta River leading to crop losses, a phenomenon that was also observed in 2018. These floods events were confirmed by officials of the Lawra District Assembly during interviews. Saodatu, a middle-aged Wangara woman succinctly described the devastating impact of the 2000 floods on the village in this statement during a focus interview session with women: "I will never forget the floods that occurred in the year 2000. We lost our farms and animals and even houses in the village. It was a year of hardship for the entire village and could be described at best with hunger and poverty". Indeed, crops are cultivated with the hope that catastrophic flooding events will not occur. Thus, this strategy ultimately produced successful outcomes in years were there are no flood events.

Finally, village savings and loans associations (VSLA) have co-evolved with the above mentioned adaptation strategies. Like the above strategies, these schemes were facilitated by NGOs. Indeed, the first VSLA was formed in Bagri in 2014 by the ACDEP a local NGO as part of a climate change adaptation project in the village. Since then, these schemes have increased to eight. As mentioned by project officers, the aims of these financial schemes were to provide farmers with ready financial resources and access to agricultural inputs. In addition, subscribers to these schemes were networked with certified agricultural input dealers and extension officers in Lawra, the district capital. About 40.1% of households in our survey were members of these NGO led financial schemes and networks. Indeed, respondents observed that, they were able to implement the crop adaptation strategies described above largely due to loans contracted from these financial schemes and networks.

However, the CCE induced barriers experienced in the village have undermined the implemented adaptation strategies and caused so many crop failures that farmers have become financially indebted. Respondents were often unable to repay loans that they had received in order to implement the described agricultural strategies because of failing agricultural production. Thus, because of CCEs, loans contracted to implement crop adaptation strategies did not usually produce the desired outcome of good yields. At the same time, loan created financial indebtedness and burdens for respondents. Climate change extremes in this way made farmers‟ less credit-worthy, and weakened their access to future loans. Some respondents have even been excluded from financial schemes and networks because of their failure to repay loans they contracted. The words of Yangnubaar, a 34-year-old female farmer summarizes an oft expressed opinion on the matter: "the rainfall pattern over the years have become like a lottery. Drought, excessive temperatures, crop pests all have become severe,

making farming less rewarding. Year in year out, we make losses due to drought to the extent that we are unable to pay back loans we contracted to buy farm inputs ".

4 Discussion

Sub-Saharan Africa presents a unique setting for the exploration of the complexity of adaptation challenges (Niang et al., 2014; Shackleton et al., 2015). This is because of persistent poverty, low levels of economic development and a high reliance on climate sensitive livelihoods within highly dynamic and challenging climatic contexts (IPCC, 2014; Tschakert and Dietrich, 2010). This paper has aimed to examine the connection between climate change related events such as droughts and floods and barriers to succesful adaptation. It does so by specifically focusing on incremental agricultural adaptation strategies already taken up by smallholder farmers to adapt to climate change. In accordance with previous studies in northern Ghana and elsewhere in SSA, it is perceived by respondents that the study village has experienced climate change accompanied by increasing CCEs (Adu-Prah et al., 2017; Bawakyillenuo et al., 2016; Sylla et al., 2016). When meteorological data (Figures 2 and 3) was compared with smallholder farmers" perceptions of climate change (Table 1), the results was more or less consistent with erratic rainfall patterns and a decline in annual rainfall amounts in the last 30 years.

Given the significance of rain-fed agriculture in developing countries, there is increased attention to how smallholder farmers have responded to climate change and the gamut of factors that hamper adaptation strategies (Antwi-Agyei et al., 2016; Osbahr et al., 2010). Shackleton et al (2015) argue that much of the existing literature on barriers to climate change adaptation in Africa reflects the already known and easily detected non-climatic barriers, i.e., financial, socio-cultural, informational and governance barriers. However, contrary to these previous studies, this study focused on climate change and barriers to successful adaptation. The results of this study provide insights that indicate that, not only climate change per se, but rather, increasing CCEs associated with climate change that remained enormous barriers to successful adaptation. This perspective we find to have received little attention in the barriers to adaptation literature in SSA (Amegnaglo et al., 2017; Boyd et al., 2013; Jones and Boyd, 2011).

Indeed, the incremental adaptation strategies implemented to adapt to climate change were insufficient at adapting to the increasing trend and frequency of CCEs in Bagri. For example, drought stalled the use of fertilizer, prevented minimal tillage and weeding practices. Floods and heavy rainfall swallowed crops and washed off fertilizer and pesticide applied on crops respectively. Thus, there is an urgent need to focus on CCEs in adaptation planning by stakeholders at both local and national scales in SSA. This is especially so because, climate projections indicate that, indeed, CCEs would constitute a large part of the future climate of SSA (IPCC, 2014; Sylla et al., 2016; Lennard et al., 2018). More importantly, empirical models do show that agriculture production, the mainstay of the majority of people living in SSA is likely to decline (crop yields) as a result of increasing CCEs associated with climate change (Roudier et al, 2011; Schlenker and Lobell, 2010; Connolly-Boutin & Smit, 2016).

Thus, whilst earlier studies (Boyd et al., 2013; Singh et al., 2018) have highlighted that, a lack of information on climate change and CCEs contribute to the inability of smallholder farmers to adapt, the results of the present study suggest that, although, information on climate change and associated CCEs may be useful for aiding the planning of adaptation activities such as fertilizer and pesticides use, information alone might be inadequate. For example, the results of this study highlight that, it is impossible to salvage already cultivated improved crop varieties on fields from windstorms, floods and droughts even when smallholder farmers have information on climate change related events. In addition,

providing timely and accurate information on climate change related extreme events to smallholder farmers still remains an arduous task, as to date, little is known about CCEs associated with climate change in SSA (Seneviratne et al., 2016; Sylla et al., 2016), or elswhere for that matter (IPCC, 2018).

Furthermore, whilst recent studies (e.g. Deutsch et al, 2018) have established relationships between temperature, crop insects and reduced yields in maize, rice and wheat crops emphasizing the direct impact of climate change parameters (e.g. temperature) on crop yields. The results here suggest the need for an addition to this framing focusing on the impact of climate change and associated extreme events on crops in combination with incremental agricultural adaptation strategies allows us to better understand the gamut of factors that might impede successful adaptation. These results show that, climate change together with CCEs directly or indirectly undermined improved crop varieties as well as other supporting incremental adaptation strategies such as minimal tilling and weeding practices needed for their cultivation in order to adapt.

This finding, contrasts with the emerging literature on climate-smart agriculture that advocates that conservation agricultural practices including minimal tillage and weeding practices enable farmers to better adapt to climate change (Partey et al., 2018; Zougmoré et al., 2018). Indeed, as shown here, despite farmers in Bagri having already adapted and implemented minimal tillage and weeding strategies, they were in several instances unable to successfully implement these strategies due to climate change and associated extreme events. For example, drought and heavy rainfall made it difficult for tilling and weeding to take place as top soils were hard or sticky because of excess water in the soil. This finding is important in that it „rings the alarm bell" for stakeholders to open up further discussions on how and what might be needed to adapt to the increasing frequency CCEs associated with climate change when incremental adaptation strategies are planned. We suggest therefore, that transformational adaptation needs more attentions, especially in SSA where it is still new and have not been implemented on a large-scale (Carter et al., 2017).

In summary therefore, socio-cultural and economic barriers to the uptake of adaptation strategies are well known in SSA (e.g. Nielsen and Reenberg, 2010; Antwi-Agyei et al et al, 2015). In Bagri, many respondents have surmounted these barriers. However, the challenge for farmers in Bagri is seeing the implemented incremental adaptation strategies through to successful outcomes. New or rather different barriers to the adaptation process (beyond uptake) are constantly emerging with CCEs associated with climate change being examples. Therefore, if adaptation is indeed, a process (Adger et al., 2005; Eriksen et al., 2011), first, it is important that stakeholders working to overcome barriers beyond those hindering the uptake of adaptation strategies. Second, it is essential that emphasis is placed on successful adaptation outcomes (Adger et al., 2005; Barnett et al., 2015), an oft overlooked perspective in the barriers to climate change adaptation literature (Antwi-Agyei et al., 2015; Nielsen and Reenberg, 2010). Indeed, as we have clearly shown in the results of this study, the incremental adaptation strategies implemented by smallholder farmers in Bagri were not producing successful adaptation outcomes mainly due to climate change and increasing CCEs.

Finally, we have shown that climatic and non-climatic barriers remain close-knit in the adaptation process. Indeed, our results illustrate that financial barriers remained a persistent problem even after an adaptation strategy has been taken up. Climate change and related extreme events such as floods and droughts undermined agricultural adaptation strategies like, for example, the use of fertilizers and pesticides. This made it extremely difficult for many of our respondents to repay loans that they had obtained to implement incremental adaptation

agricultural strategies. This finding is an addition to the existing literature that focuses on financial barriers to the uptake of agricultural adaptations strategies (Antwi-Agyei et al., 2015; Asfaw et al., 2018).

5 Conclusion

The aim of this paper has been to examine the connections between climate change and barriers to successful adaptation outcomes. Preceding from the basis that climate change, together with increasing climate extreme events such as droughts and floods are perceived to be ongoing in our studied village over the last 30 years, the importance of using improved crop varieties, fertilizers and pesticides, the cultivation of valleys and marshy fields, and loans and savings schemes as incremental adaptation strategies have been shown to have coevolved with climate change and increasing CCEs in the village studied.

Yet, our results suggest, paradoxically that, incremental agricultural adaptation strategies implemented were not producing the desired results. This was mainly because, in many instances, these strategies were undermined by increasing CCEs accompanying climate change. The results presented in this paper therefore show that yields of improved crop varieties were far lower than actual potential. Climate change and CCEs was a major barrier as they undermined flowering and pollination processes of improved crops cultivated to adapt, and in some cases, caused seed and crop death. Likewise, droughts, dry spells, and heavy rainfall prevented effective implementation of incremental agricultural adaptation strategies such as fertilization, the application of pesticides, and minimal tilling and weeding practices highlighting the vulnerability of different adaptation strategies to CCEs associated with climate change.

Finally, we have demonstrated that, financial barriers still persisted even after they have been surmounted at the uptake stage in the adaptation process with CCEs associated with climate change being main contributing factors. Indeed, CCEs increased financial indebtedness as many of our respondents were unable to repay loans they had obtained in order to implement the afore mentioned incremental agricultural adaptation strategies. Thus, our results highlight that, the uptake and implementation of an adaptation strategy is a necessary but not sufficient condition to successful adaptation outcomes, where, climate change and CCEs remain or become unavoidable.

Chapter III

The role of social networks in building adaptive capacity and resilience to climate change: A case study from northern Ghana

This is an accepted manuscript of the following article: Dapilah, F., Nielsen, JØ, & Friis, C (2019) The role of social networks in building adaptive capacity and resilience to climate change: A case study from northern Ghana. *Climate and Development.* 12:1, 42-56. © 2019 Informa UK Limited,Taylor & Francis Group. The final version is available at Doi.org/10.1080/17565529.2019.1596063.

Men from Bagri selling livestock at Zambo, Burkina Faso

Hut of Daniel, a migrant fisher from Bagri in Dokyere

Abstract
Increasing attention is being paid to the role of social networks in climate change research and new studies show that they form an essential source of resilience. However, the role of social networks remains underexplored as there is only limited empirical evidence of their benefits, particularly for research on adaptation to climate change in developing countries. This paper provides a contribution to this field of research by examining how social networks foster livelihood diversification and resilience in a small rural community in northern Ghana. The study combines semi-structured interviews, focus group discussions and a survey with a range of other participatory methods. The findings show that, people in the studied community have experienced a range of climatic changes with negative impacts on agriculture in the last three decades. These climatic changes have forced community members to diversify their livelihood activities away from crop production and into off-farm and non-farm activities. Our results highlight how the process of diversification is dependent on household participation in various group activities and formal and informal social networks. Further, the households participating in several group activities and social networks had more diverse livelihood strategies and were found to be more resilient to perceived climate changes because they had access to the critical resources (material and non-material) essential for diversification through their networks. Importantly, this study shows how group activities and social networks can also create adverse effects by enforcing exclusion and marginalization among certain groups in the community. In addition, it shows how some diversification strategies are in conflict with others and thus may potentially undermine future adaptive capacity and the resilience of the community as a whole.

1 Introduction

The impacts of climate change on natural and agricultural ecosystems and human societies over the last three to four decades are indisputable (IPCC, 2014; 2018). As one of the critical phenomena of the 21st century, climate change is expected to exacerbate immediate development stresses through the scarcity of ecosystem services and increased frequency and intensity of loss event (Sissoko et al, 2011; Field, 2014). The trend is expected to continue in the future (IPCC, 2014; Red Cross Crescent, 2013). The impact of climate change on societies and economies differs globally with developing countries being hit the hardest (Niang et al, 2014). As climate and extreme weather events become more frequent, as well as more unpredictable, there is an urgent need for support that will help communities in developing countries build stronger resilience.

In the search for a strategic response to climate change risk in socio-ecological systems, the concept of „resilience" has rapidly gained a strong foothold in discourses and been integrated into research agendas and policy goals at the national and global level (IPCC, 2014; UNISDR, 2015). Among researchers, policy-makers and civil society actors, there is an urgent drive to understand how resilience can be facilitated, supported and sustained (Adger, 2003; Berkes and Ross, 2016). This is especially so because, resilience is seen as an important conceptual framework that will help us to understand how communities can adapt to climate change (Wilson, 2012; Bahadur et al, 2013; Berkes et al, 2003; Adger, 2000). A resilient system is one that has the capacity to absorb disturbance and reorganize while undergoing change and still retain essentially the same function, structure and identity (Berkes et al, 2003; Walker et al, 2010). Adaptive capacity is a central element of resilience within the field of climate change adaptation. The IPCC defines adaptive capacity as the „ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences" (IPCC, 2007:72). More specifically, it involves the ability to mobilize social and physical elements to enable adaptation and reduce vulnerability (Nelson et al, 2007; Smit and Wandel, 2006). Adaptive capacity is not static and evenly distributed within populations (Walker et al, 2004; Berkes et al, 2003) and is primarily framed in the climate change literature as conditions that enable a system to cope with, adapt to and recover from climatic stress (e.g. Walker et al, 2004; Smit and Wandel, 2006; Nelson et al, 2007). Other studies have explored the socio-economic and physical factors which enhance or reduce adaptive capacity (e.g. Adger, 2000, Walker et al, 2004). In this study, we focus on the adaptive capacity of households to manage and influence their resources and risk through group activities and social networks.

There is a general consensus that social networks form an important component of adaptive capacity and resilience (Berkes and Folkes, 1998; Adger, 2003). As a result, there has been an increasing surge in the use of social network perspectives in resilience research on socio-ecological systems (Bodin et al, 2011; Tompkins et al, 2002; Robinson and Berkes, 2011; Adger, 2003). The integration of a social network perspective in climate change adaptation and resilience research in resource-dependent societies show that households seldom undertake adaptation decisions on their own (Osbahr et al, 2010; Ireland and Thomalla, 2011). Instead, adaptation decisions are often based on interactions between people and their collective activities, which are mediated through kinship, friendship and informal institutions, as well as formal governmental institutions (Adger, 2003; Goulden et al, 2013). However, only limited empirical evidence is available of how social networks enhance resilience during climate change and climate variability in developing countries (Rockenbauch and Sakdapolrak, 2017; Adger, 2003; Goulden et al, 2013; Ireland and Thomalla, 2011; Osbahr et al, 2010). For example, Ireland and Thomalla (2011) mentioned that, while it is evident that social networks can act as enablers for climate change adaptation, their role in enhancing

resilience is not precisely understood. Indeed, in their recent review, Rockenbauch and Sakdapolrak (2017) argue that the role of social networks in the resilience of natural resource-dependent communities in the face of climate change remains under-researched and under-conceptualized, particularly in the developing countries.

This paper is placed within this empirical knowledge gap. It specifically examines two types of group activities and social networks that were found to be important for livelihood diversification and resilience during climatic change and variability in a small natural resource-dependent community in northern Ghana. These are comprised of organized and organic groups that are engaged in collective activities that amount to social networks in which members have established relations with formal institutions and individuals outside of the community. While the objective of the paper is not to offer a comparative perspective as such, by looking at both types of groups, we are able to show how these different group activities facilitate livelihood diversification. This is important for discussions on climate change adaptation in developing countries. We ask the following two overarching research questions: (1) what are the diverse group activities that have emerged in response to climate change and diminishing agricultural outputs in Bagri in the last three decades? (2) Do group activities open up access to new social networks and livelihood diversification options to enhance adaptive capacity to climate change?

The findings show that the community studied is perceived by the respondents to have experienced climate change with negative impacts on crop production. To adapt, households have had to diversify their livelihoods away from crop production and towards non-farm and off-farm livelihood activities such as trade, migratory fishing, horticulture and micro-scale processing (for example, shea butter and soap production). Socio-economic status and participation in the group activities of households was found to be a significant determinant of engagement in and diversity of social networks. The results also illustrate that some livelihood strategies undertaken within groups are in conflict with each and have maladaptive outcomes that potentially undermine the future social and ecological resilience of the community. Therefore, this paper provides an empirical understanding of both the positive and potentially negative aspects of group activities and social networks in relation to climate change adaptation and resilience.

The paper is organized as follows. The next section presents the theoretical framework based on how social networks foster livelihood diversification and resilience during climate change. We then describe the study setting and methods in section three and four respectively. The results section of the paper is presented in five main parts. The first and second part describes perceived climate change among villagers in the study site over the past three decades and its impacts on their livelihoods. The third part identifies and maps the different forms of social networks in response to perceived climate change. This is followed by results on the benefits of group activities, both organized and organic and how they facilitate livelihood diversification and adaptive capacity to climate change. Finally, the last part presents the results of the negative outcomes of group activities and livelihood diversification on community social and ecological resilience. Subsequently, in section six, we discuss the implications of our results in relation to the role of social networks in the climate change adaptation literature. We conclude the paper in section seven.

2 Theoretical perspectives

A social network is defined as a group of people or organizations that form a constellation of relationships (Magsino, 2009). These are in turn defined by patterns of vertical and horizontal relationships or ties (Granovetter, 1973; Putnam, 2000). A horizontal relationship is understood as referring to a network with high levels of familiarity, and it typically entails an

implicit commitment to reciprocity involving individuals typified by kinship or religion (e.g. friends and relatives). Vertical networks are social relationships of exchange, often of associations between people with shared interests or goals but contrasting social identities or weaker bonds, for example community groups and formal state institutions (Putnam, 2000; Magsino, 2009). The climate change adaptation literature recognizes the significance of social networks in adaptation and transformation in social-ecological systems (Adger, 2003; Osbahr et al, 2010). In particular, social networks are important for livelihood strategies and livelihood diversification, which is a crucial component of adaptation to climate change in resource-dependent communities in developing countries (Barrett et al, 2001; D'haen et al, 2014). Livelihood diversification is defined as „the process by which (rural) households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living" (Ellis, 2000: 14). Diversification strategies are broadly categorized into on-farm (mix of agricultural activities, e.g. crops, livestock), off-farm (wage or labour exchange within agriculture e.g. income from fuelwood sales and labour), and non-farm activities (non-agricultural income such as rural wage or salary employment) (Barrett et al, 2001; Ellis, 2000). For Sub-Saharan Africa, numerous studies show that there is high prevalence of livelihood diversification among rural households in response to climate change and diminishing agricultural yields (e.g. Nielsen et al, 2012; Antwi-Agyei et al, 2014; Barrett et al, 2001; D'haen et al, 2014).

Social networks have been shown to give people the capacity to adapt to and shape change by providing resources essential for livelihood diversification (Moore and Westley, 2011; Nelson et al, 2007), as well as by fostering their ability to initiate social innovations and act collectively (Newman and Dale, 2005; Moore and Westley, 2011; Rotberg, 2013). In agriculture and agroforestry, it has been shown that important information on new technologies and more sustainable management practices flows, to a large extent through ties facilitated by such networks (Isaac and Matous 2017; Spielman et al, 2011). Similarly, it has been revealed that social networks improve collaborative governance processes by facilitating the generation, acquisition and diffusion of different types of knowledge and information essential for diversification (Isaac and Matous, 2017; Crona and Bodin, 2006). Tompkins and Adger (2004) suggest that social networks open up new lines of communication with government institutions that are capable of assisting with adaptation measures at the community level. Likewise, other studies suggest that social networks offer poor and marginalized groups an opportunity to develop new and innovative ways of adapting to climate change often through livelihood diversification (Robinson and Berkes, 2011).

Social network analysis highlights a number of characteristics within networks that are essential for diversification (Newman and Dale, 2005; Prell et al, 2009). Granovetters" research on the strength of ties between actors show how strong versus weak ties relate to different sets of outcomes (Granovetter, 1973:1361). He notes that, „the strength of a tie is a (probable linear) combination of the amount of time, the emotional intensity, intimacy (mutual confiding), and reciprocal services which characterize the tie". Actors sharing strong ties tend to: (1) influence one another more than those sharing weak ties, (2) share similar views, (3) offer one another emotional support and help in times of emergency, (4) communicate effectively regarding complex information and tasks, and (5) be more likely to trust one another (e.g., Barnes et al, 2016; Crona and Bodin, 2006; Prell et al, 2009; Newman and Dale, 2005). The advantages of strong ties for livelihood diversification are obvious: networks with strong ties are likely to influence information sharing and learning and provide mutual help through lending, borrowing and the exchange of family labour and resources (Gong et al, 2017; Crona and Bodin, 2006; Prell et al, 2009; Newman and Dale, 2005). However, it is also often noted that strong ties can become „self-containing" (redundancy of information) meaning that people tend to possess the same information (Prell et al, 2009; Barnes et al, 2016). Diverse information and new ideas can also travel through weak ties and

offer actors in these networks access to a diverse pool of resources and information (Granovetter, 1973). For example, research has shown that, weak connections with the external world (e.g. NGOs) allow farmers to have access to external resources (Gong et al, 2017; Isaac, 2012; Robinson and Berkes, 2011). Research also shows that resources are necessary for the successful adoption of agricultural practices (Lubell et al., 2011) or become adaptation strategies in and of themselves (Nielsen et al, 2012). Despite the advantages associated with weak ties, one of their potential drawbacks is that they may easily break or decay (Prell et al, 2009). Further, networks sharing weak ties may lack the understanding and trust essential for dialogue over adaptation options (Burt, 2004; Newman and Dale, 2005).

Closely related to the discussion regarding strong and weak ties is the concept of homophily. Homophily refers to a social selection process in which there is a tendency for people to disproportionately form social ties with others who are similar to themselves (Bodin and Crona, 2009; Barnes et al., 2016). One effect of homophily is that it leads to dense social networks in which one or a few individuals hold the majority of ties with others in the network (Prell et al, 2009; Barnes et al., 2016). It is often noted that stakeholders who are similar to one another are better able to communicate tacit and complex information, as there tends to be higher mutual understanding between actors (Prell et al., 2009). However, research has shown that such dense networks largely fail to extend to groups in which there are different traits or a set of traits (Moody, 2001). This can be especially problematic in linked social-ecological system as successful climate change adaptation requires the integration of diverse views and opinions (Newman and Dale, 2007).
The importance of the structure of the networks for the transfer of adaptation options is similarly captured by the concepts of „degree centrality" and „betweenness centrality". Degree centrality refers to the number of networks that stakeholders are directly connected to (Cassidy and Barnes, 2012). A high degree centrality can enhance resilience and reduce redundancy (i.e. the flow of the same information) by facilitating access to new information, social learning and trust for stakeholders who are members of more than one network (Cassidy and Barnes, 2012). In addition, stakeholders with high degree centrality are deemed to be important players for mobilizing the network and bringing other stakeholders together (Prell et al, 2009). Accordingly, „betweenness centrality" refers to the number of times a stakeholder acts as a bridge between two other stakeholders in a network (Wasserman and Faust, 1994; Bodin and Prell, 2006; Cassidy and Barnes, 2012). Actors with high „betweenness centrality" are important because they play a broker role of bringing together disconnected segment of a network and/or two or more networks (Prell et al, 2009; Bodin and Prell, 2006). Entrepreneurial and innovative opportunities in networks are created by brokers (Burt, 2004:12). In the context of climate change adaptation, broker attributes are important for transformative change as they are crucial for the diffusion of information and innovation. Moreover, they tend to be entrepreneurial facilitate innovative opportunities in the networks in which they are embedded (Rotberg, 2013). They can often "see how a belief or practice in one group could create value in another group" (Burt, 2004:355). However, brokers may feel torn between the different elements of the networks and feel like they are forced to take sides particularly in cases of resource or land use conflicts (Krackhardt, 1992; Prell et al., 2009).

The burgeoning discussion of, and emphasis on social networks in the global environmental change research community, is therefore highly relevant with regards to their importance for adaptation to climate change options (Barnes et al, 2017; Rockenbauch and Sakdapolrak, 2017; Henry and Vollan, 2014). However, they need to be well understood, so as to fully harness their ability to build resilience during climate change. It is to this task that we now turn.

3 The study setting

The northern regions of Ghana, located in the Guinean Savannah ecological zone, have experience increasing climate variability in recent years as a result of climate change (MEST, 2013; Yaro, 2013; GSS, 2012). As a result, the population of northern Ghana has to adapt to these changes. The impact of climatic changes is particularly problematic in northern Ghana where poor socio-economic conditions combined with policy neglect, political marginalization, poor infrastructure, localized conflict, rapid population growth and low investments has made the population very vulnerable to climate change (MEST, 2013; Yaro, 2013; GSS, 2012). The dry nature of the savanna zone and the short rainy season, limits crop production to only those crops that have a short life cycle (Adamu, 2000). Official records from the Ghana Statistical Service (GSS) show that, although only 22.0% of the total Ghanaian population is living in the three northern regions of the country (Northern Region, Upper East Region and Upper West Region), 80 per cent of all of those who are extremely poor in Ghana are residents of one of the three northern regions (GSS, 2012).

The Lawra District where our study took place is located between latitude 10.35˚ and 10.40˚ north and longitudes 2.50˚ and 2.53˚ west and covers a land area of 527.37 km^2. This places the district in Guinea Savanna zone, an area that is vulnerable to climate change (Serdeczny et al, 2015). This zone is characterized by shrubs and scattered drought-resistant trees such as shea, baobab, locust bean and ebony. There is a distinct change in vegetation cover during the two distinct seasons of the year with extensive greening of the vegetation in the rainy season (April-October), and withering of vegetation in the dry season (November-March) (Adu-Prah et al, 2017). Farming, therefore, is mainly possible in the wet season.

In this paper, we focus on Bagri village (Figure III-1) which is about 15 km away from the district capital Lawra town, and located on the border to Burkina Faso. Bagri consists of 198 households and has a population of 1,040 (Male: 514; Female: 526) (GSS, 2012). It is estimated, however, that the population grew from 1,040 up to 1,196 in the year 2017 (GSS-Wa Regional Office, 2017). The community is mainly inhabited by the Dagara ethnic group but also includes households from other minority ethnic groups including Hausa, Wangara and the Fulani. Religion is highly segregated along ethnic lines with the Dagara practicing Christianity and traditional religion. The Hausa, Wangara and Fulani practice Islam.

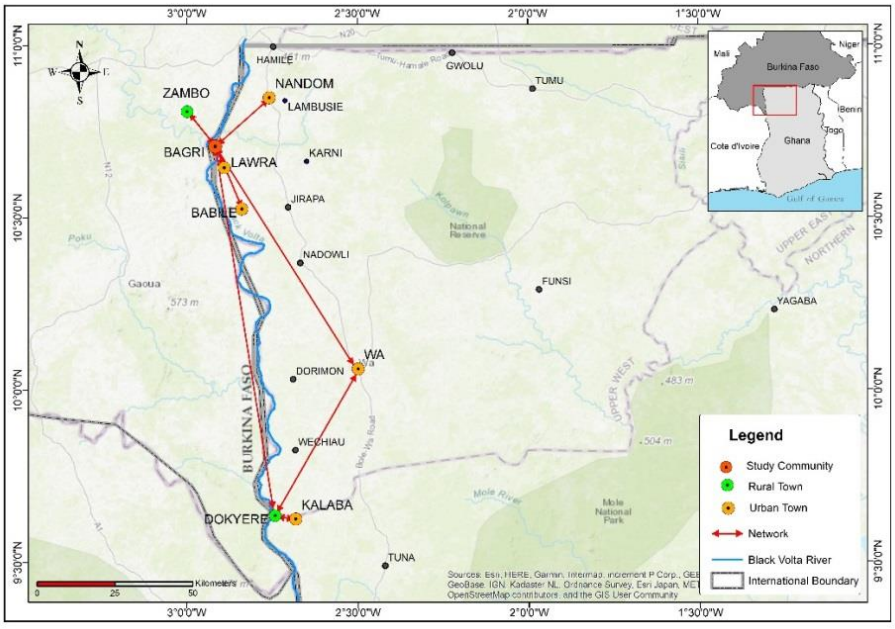

Figure III: 1: Map showing the location of Bagri in the Upper West Region of Ghana

Residents of Bagri engage in multiple livelihood activities with crop farming being the mainstay. However, the closeness of Bagri to Burkina Faso and the Black Volta River allows other (off-farm) economic activities such as dry-season horticulture, fishing and trade. Economic activities are also diverse between the ethnic groups with a majority of the Dagara engaging in crop farming. Hausa and Wangara mostly engage in fishing and trade whilst the Fulani specialize in cattle rearing.

No meteorological records exist for Bagri, but in Babile, the nearest town with a weather station, rainfall and temperature data has been collected since 1975. This data show that the climate of the area is highly variable. The mean annual temperature ranges between 27˚c and 36˚c with annual rainfall amounting to 1000-1100mm. The available datasets suggest that annual rainfall was slightly higher in the 1970s than in the 1980s, but that it has gradually recovered since the 1990s and 2000s (Figure III-2). Likewise, the datasets show a slight increase in the maximum and minimum temperature from 1990-2014 (Figure III-3). This mirrors the general trend for the entire savanna ecological zone and the country at large (Adu-Prah et al, 2017; Owusu, 2017).

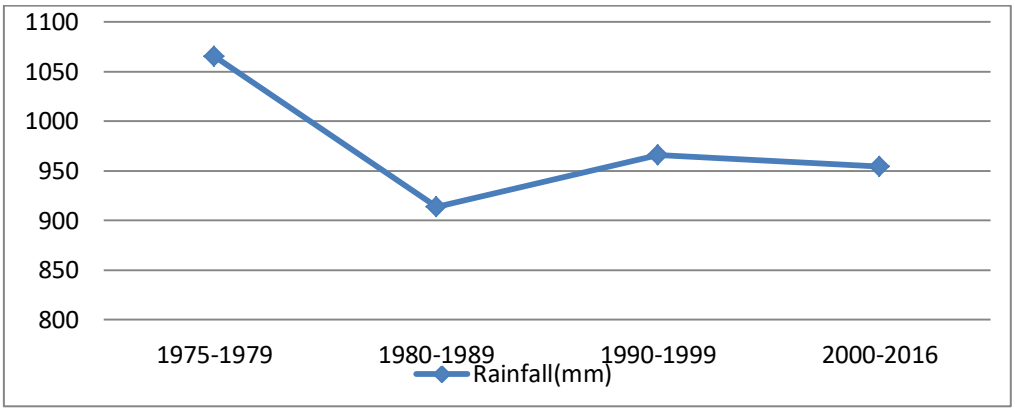

Figure III-2: Average rainfall data for Babile (1975-2016)
Source: Adapted from GMet weather station, Babile

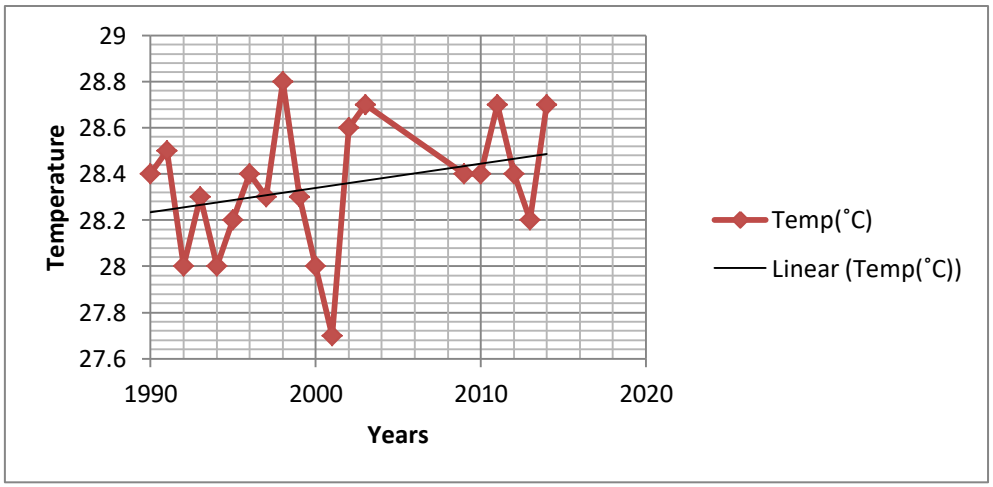

Figure III-3: Average temperatures for Babile (1990-2014)
Source**:** Adapted from GMet weather station, Babile

The population of Bagri is therefore faced with increasing pressure to adapt and respond to climate change and variability and they have largely done so through livelihood diversification. They often respond through collective activities based on informal (kinship, friends and relatives) and formal (governmental and donor/civil society organizations) social networks. Since the drought period of the 1980s, the community has received several development interventions including climate change adaptation projects from both national (e.g. ACDEP) and international (e.g. CARE, OXFAM) donor and civil society organizations as well as from the United Nations development agencies (e.g. UNDP).

4 Methods

The empirical data for this study was obtained between February and July, 2017. Table III-1 presents the methods used and the issues examined. Semi-structured interviews, focus group discussions, observations and a survey were the main methods used. These were supplemented with informal conversations and transect walks to ascertain community adaptation strategies to climate change. The semi-structured interviews were conducted with older, middle-aged and young men and women across ethnic, occupational and wealth groups in the community. The respondents were invited to talk about different aspects of their lives in relation to environmental change, local livelihood strategies and social networks. This created an in-depth understanding of the different aspirations and perceptions of the elderly and the young and differences across gender. It also revealed issues related to power dynamics and access to the resources needed to build adaptive capacity, the changes in traditional processes and structures, as well as adaptation responses to climate variability by different segments of the community. In so doing, possible solutions to local climate change adaptation barriers were outlined. In addition, semi-structured interviews were held with the officials of government agencies and non-governmental organizations working in the community to elicit the institutional capacities and interventions that have been implemented to build adaptive community capacities**.** Focus group discussions were similarly conducted with men and women separately as well as some involving both men and women. In focus group discussions, participants were asked to identify and map resources including social networks ties (formal and informal), livelihood risk ranking, trends analysis, seasonal calendar, and ranking of coping strategies. All semi-structured interviews and focus group discussions were done in Dagaare and Hausa (with the help of an interpreter) or in English when the interviewee/s was/were sufficiently fluent. All interviews were recorded and transcribed. Observations and conversations during informal conversation and transect walks were written down in field notebooks. Qualitative data from semi-structured interviews and focus group discussions were manually coded according to themes such as: climate change perceptions (change/no change, causes and impact) and adaptation strategies.

A total of 127 surveys were undertaken with household heads (out of 198 households). These were stratified to cover the socio-economic groupings in the community. The survey also captured household social network involvements and dominant livelihood diversification strategies employed by households in the study community. Data from survey was coded and inputted into SPSS version 20 to enable appropriate statistical analysis

Table III-1: Methods, thematic areas, temporal span and quantity

Methods	Quantity	Thematic area	Time span	Target sample
Semi-structured interview	Households 64 (Men-40, women-24)	Environmental and socio-economic change Livelihood assets and vulnerability Climate services and adaptation strategies Collective activities and knowledge systems	30 years back	Sampled across gender, age groups and ethnicity
	Formal institutions 14 (NGOs-6, State-8)	Role of external institutions		
		Climate change interventions and barriers	Past & present	
Focus group discussion	22 (Men -10, Women-8; Men &Women-4)	Socio-economic & biophysical change Community adaptive capacity Community Knowledge systems Role of external institutions Access to climate services	30 years back & present	Sampled across gender, age groups and ethnicity
Survey	127 households out of 198	Household profile (socio-economic assets) Perceptions and access to climate services Household adaptation strategies Migration history and links with external agencies		Household heads
Informal conversation	Presence in Bagri	Across various themes	30 years back & present	Across gender, age groups and ethnicity
Participant observation	Presence in Bagri	Daily activities, farming practices, wealth, assets owned, power dynamics	Present	Across gender, age groups and ethnicity

Source: Authors

5 Results

5.1. Perception of climate change and variability

The results from the survey show that respondents have observed changes to the climate over the time period of thirty years in Bagri (Table III-2). All respondents perceived a change in annual dry season and rainy season precipitation over the period. About 86.6 % of respondents believed annual precipitation had decreased. With regards to dry spells and intensity of rainfall events, 91.3% and 69.2% perceived that both precipitation parameters had increased over the period respectively. 74% of respondents perceived floods/inundation of fields to have increased over the time period. Moreover, the respondents observed abnormalities in rainfall timing and distribution. For instance they observed that rains now start between May/June and end in September/October compared to 30 years ago when the rains started in April and ended in October.

Table III-2: Perception of climate change and variability over the past 30 years (N=127)

Climate variables		Increased (%)	No change (%)	Decreased (%)	Can´t Tell (%)
	Annual	7.8	5.5	86.6	0.0
	Rainy season	5.5	0.0	80.3	7.8
	Dry season	0.0	93.7	1.5	4.7
	Dry spells, rainy season	91.3	6.2	2.3	0.0
	Intensity of rainfall events	69.2	15.7	11.8	3.1
Precipitation	Inundation of fields	58.2	18.1	33.8	0.0
	Dry season temperatures	88.1	0.0	4.7	7.0
Temperatures	Rainy season temperatures	69.2	10.2	4.7	15.7
	Length of cold period	14.1	3.9	74.0	7.8
	Length of hot periods	88.1	0.0	8.6	3.1
	Intensity, dry season	87.4	6.2	7.0	0.0
Winds	Intensity, rainy season	43.3	16.2	25.9	14.1

Source: Survey, 2017

In relation to temperatures, 88.1% and 69.2% of respondents suggested that dry season and rainy season temperatures had increased respectively. About 74% of respondents reported a decrease in length of cold season temperatures. Only 10.2% and 3.9% suggested that there have been no changes in the rainy season or in the length of rainy season temperatures respectively. Finally, 87.4% and 43.4% of the respondents suggested that the intensity of dry season and wet season winds had increased respectively. Only, 14.1% of the respondents could not tell if there was a change in rainy season wind intensity.

5.2. Livelihood activities and perceived impacts of climate change and variability

The people of Bagri engage in multiple livelihood activities with agriculture (crop) production being the primary economic activity. Results from the survey indicate that all households included in the survey engaged in agricultural (crop) production. The second dominant

livelihood activity was livestock/poultry (73.2%). This was followed by fishing (49.6%) and commerce/trade (47.2%). Fewer households engaged in livelihood activities such as agro-processing (31.4%) and horticulture (23.6%). Livelihood activities were distributed along ethnic and gender lines. The Hausa (29.9%) and Wangara (15.7%) specialized in fishing and trade with all households in each group undertaking these activities. The Dagara households (52.8%) were more specialized in crop production whereas the Fulani *(*1.6%) engaged mainly in livestock rearing (cattle). Similarly, livelihood activities differed by gender. Male-headed households mainly engaged in crop production (88.1%), fishing (49.6%) and livestock/poultry (88.1%). Female headed households (11.8%) mostly engaged in trade (e.g. cereals, fish, vegetables), and agro-processing (e.g. sheabutter production).

Our respondents claimed that the changes in climate have had negative consequences on agricultural production. The results show that, over the last three decades, even in the best years of rainfall, the harvest from agriculture do not meet the food requirements of most households. From the perspective of crop farmers, frequent dry spells and, a short-wet season combined with the unpredictability and reduced rainfall amount over the years have made agriculture precarious. These changes were noticed to have negatively affected planning and decisions on farm preparation, the sowing of seeds as well as fertilizer and pesticide application. For example, farmers mentioned that the increased intensity of rainfall events leads to soil erosion and washing-away of fertilizer and pesticides that have been applied on crops. Likewise, increased wet season temperatures and windstorms were found to cause scorching and withering of crops and breaking of crop stock leading to crop damage and low yields.

In the case of fishers, rainfall has a direct bearing on fish stocks in rivers. Therefore, periods of good rainfall are accompanied by more fish and vice versa. Consequently the fishers attributed the low fish catches in recent years to the declining amount of rainfall.

The impact of climate change on livestock was also enumerated by livestock owners. They revealed that, the increasing length of the dry season coupled with high temperatures causes grasses to wither fast making it increasing difficult to feed livestock, especially cattle. This leads to low milk production and malnourished cattle that attract low market prices. The intensity of winds and high temperatures were perceived as the causes of poultry diseases and poor animal health and death.

5.3. Group activities and social networks in response to climate change and dwindling agricultural production

The proliferations of development projects (over 15 new projects) by donor and development agencies in Bagri since the late 1990s and early 2000s was a clear response by donors to the increasing vulnerability of agriculture to climatic change and variability (Plate III-1). Climate change and its impacts on agriculture, combined with the development of projects aimed at negating these impacts has led to the emergence of two main identifiable groups formed around collective livelihood activities, which further aid the establishment of social relations with organizations and individuals outside of the community. However, group formation, collective activities, interaction and flows of resources within and between groups and their social networks have differed. We lump groups and collective activities together as organized or organic in order to represent these differences. Organized groups were spurred by the increase in development projects by NGOs targeting climate change adaptation through livelihood diversification which has led to an increasing recognition of and move towards collective activities. Organic groups were formed to facilitate certain economic activities, by villagers themselves, mainly in response to dwindling agricultural production resulting from climatic changes. The two analyzed types of groups allowed the members to form social networks with weaker or stronger ties and with actors outside of the community. All groups included in this study have been in existence for atleast three years. Finally, we also defined

households that had no memberships in organized and organic groups as „non-group". The survey on group membership indicates that about 62.3% of households were members of organized and/or organic groups. The remaining 37.7% were non-group households (Figure III-4).

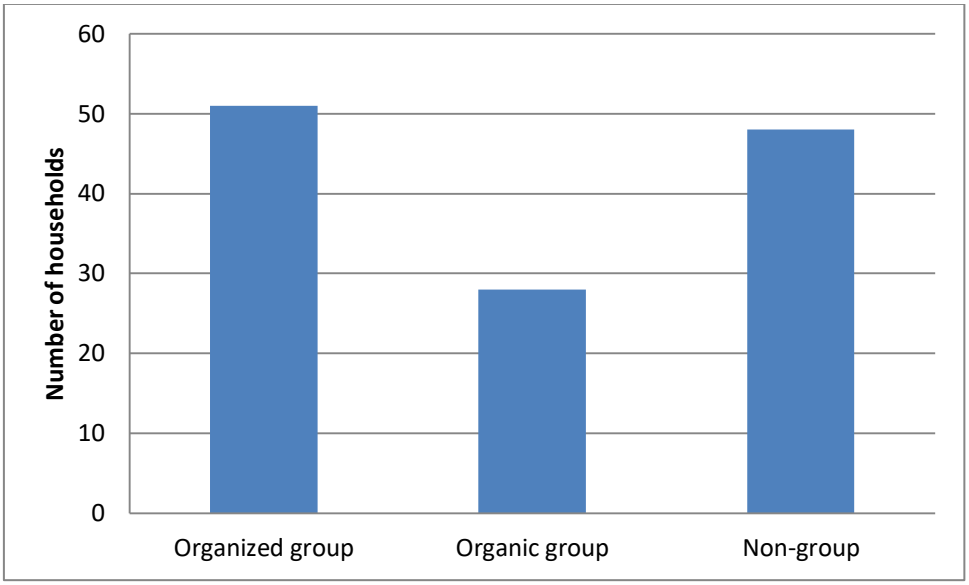

Figure III-4: Household membership in groups (N=127)

Source: Survey, 2017

Plate III-1: Examples of past and ongoing climate change adaptation projects in Bagri

Source: Authors, 2017

5.3.1. Organized groups formed by non-governmental organizations

About 40.1% of households held membership in organized groups formed by the Association of Church-Based Development NGOs (ACDEP) in 2014. In supporting the community to build livelihood resilience during climate change, ACDEP emphasized the importance of group formation and the integration of groups into networks mainly with formal institutions outside of the community. As was explained by a fieldworker of ACDEP, the major reason behind group formation was that: "they were cost-effective, ensured access to diverse resources both material and non-material and were easier to manage". The field officer further mentioned that "we build their capacity and network them with institutions so that that farmers get to know who to contact and where to get essential resources to enable them adapt their livelihoods to climate change even after our projects fold up".

The concept of homophily, i.e. the tendency for people to disproportionately form social ties with others similar to themselves also played out in group formation and collective activities. Groups were always formed around a common interest, occupational lines or needs of the members related to livelihood preferences. For example, individuals who were interested in crop farming were selected as one group by the NGOs who then connected the group to agricultural extension officers, agricultural input dealers, climate and weather information providers and agricultural marketing companies. Five such groups formed by NGOs were identified during the fieldwork (Table III- 3): crop, livestock, horticulture, sheabutter and soap production and village savings and loans associations (VSLA).

Table III-3: Group contacts with external institutions/individuals in the last five years

Groups/activities	Households (N=127)	State	NGOs	firms	Individuals
Organized	***(n=51)***				
VSLA	41	40	41	41	28
Crop farmers	45	45	45	45	45
Livestock farmers	15	15	15	10	15
Horticulture farmers	20	16	20	20	20
Shea butter/soap producers	17	17	17	17	17
Organic	***(n=28)***				
Migratory fishing	22	8	10	15	15
Fuelwood traders	10	7	10	6	10
Traders in agro-products	17	17	12	25	25
Non group	***(n=48)***	21	6	10	34

Source: Survey, 2017 NB: some households had members in more than one group

The NGOs identified group members through a survey of household assets and, the aim was to identify the poorest and most needy households. Participation in NGO formed groups with the exception of village savings and loans associations did not require any financial commitment for membership, making them readily available to even poor households. All groups formed by NGOs elected their leaders democratically. Members were also trained on business development skills such as record keeping, group dynamics and conflict resolution. The results of our survey showed that membership in groups that were established by NGOs differentiated across gender, wealth and age. All female-headed households (100%) had membership in groups led by NGOs compared to 78.5% of households headed by men. The reason for this was that, NGOs gave priority to women in climate change adaptation projects because women were considered both more vulnerable and more reliable.

5.3.1.1. Training, capacity development and access to services for on-farm diversification

Groups formed by NGOs had frequent access to external resource persons such as agricultural extension officers who trained them on demonstration farms established in 2014 by ACDEP in Bagri. This training included agronomic practices such as tilling, sowing and spacing of crops, mixed cropping and fertilizer and pesticides application. In addition, groups were introduced to new improved crop varieties all aimed at boosting agricultural outputs. Mercy, an agricultural extension officer mentioned that: "before the on-set of the season, we take the farmers through a number of agronomic practices on the demonstration farm so that they can in turn replicate them on their own farms". Hajia Hamida an agricultural input dealer and a so-called nucleus farmer who trains other farmers on behalf of the USAID funded

project, ADVANCE, mentioned that "farmers will only adapt to new farming practices when they are able to compare results of the new farming techniques with their traditional practices. The demonstration farms are helpful as it has changed many farmers to adopt modern farming practices". Mariama, a beneficiary of the crop farmers" group extolled the intervention of ACDEP: "we used to burn farm residues, sowed our crops haphazardly and also did not know how to till farm plots to conserve moisture or reduce water erosion but now we do know all of these strategies". Our household survey results corroborated these. In general, many households in networks used different on-farm diversification strategies compared to households that did not participate in group activities (Table III-4). For instance, 77.2% and 72.1% of households in organized and organic groups used improved seeds and fertilizer/pesticides on their farms respectively compared to only 37.5% and 58.3% in non-group households. Participants in groups mentioned that they do see improvement in agricultural yields when these strategies were implemented. The oft mentioned advantages of improved crop varieties were: drought tolerance, short duration to maturity (often between 60-90 days) and high yielding (quality and quantity) as compared to non-improved crop varieties. The use of fertilizers and pesticides facilitated early crop growth to meet short rainfall season and prevented crop pests and diseases. The farmers further argued that the use of mulching and mixed cropping techniques prevented soil erosion caused by flooding. The improved techniques also protected the soil from heat and crops from exposure to excessive winds. Moreover, NGOs formed groups were connected with the private company Essoko. Essoko provided weather forecast and price information of agricultural goods at various markets centers via mobile phones to beneficiaries. This enabled the farmers to plan their farming activities (to better hit the onset of the rainy season) and to determine where and when to sell their agricultural goods at competitive prices. These were the words of Pognaa, Queen mother of Bagri during a focus group discussion: "In the past we did not know where to buy improved seeds, fertilizers/pesticides. Neither were we able to predict the rains nor sell our goods at higher prices. But now, we get all these information and also buy the agricultural inputs from Hamida Enterprise the fertilizer agent in Lawra. This was all made possible by ACDEP". Overall as shown in Table III-4, participants in group activities exhibited „degree centrality" and „betweenness centrality" compared to non-group households as they had more contact with external institutions and also acted as a as a bridge between NGOs, agricultural extension officers, agricultural input firms and climate information providers which facilitated access to new information, social learning and trust.

Furthermore, livestock farmers were trained on animal husbandry, assisted with material resources such as cement to construct shelter for animals, and provided with improved animal breeds (Sheep). In addition, ACDEP provided vertinary services to all beneficiaries of their livestock project. According to our respondents, the improved sheep breed attracted high market prices because they „grow bigger and multiplied faster" than the traditional breed. As such, they served as assets that were easily converted into cash in times of need to support household livelihoods. For example, livestock were sold to purchase food, agricultural inputs etc. Finally, VSLA encourage savings and provided easy access to loans at low interest rates that enabled participants to diversify into other livelihood activities such as trade. Thus, VSLA enabled many of our respondents to overcome financial barriers to climate change adaptation.

5.3.1.2. New knowledge and innovation in livelihood diversification

Organic groups were provided with new knowledge and innovation in non-farm and off-farm livelihood diversification in horticulture and shea butter and soap production which was all alien in the community. During the fieldwork, three horticultural and two shea butter and soap production groups were identified to be operating with members ranging between two to ten

established by ACDEP. About 15.7% and 13.3% of households in our survey were members of the horticulture and shea butter processing and soap production groups respectively.

By virtue of the location of Bagri close to the Black Volta River, ACDEP introduced horticulture for beneficiaries to tap on the water resource during the dry off-farm season. Groups in horticulture were trained on the cultivation of high value vegetable crops such as okra, onion, cabbage and lettuce. In addition, they were provided with inputs such as seeds, fertilizer and pesticides. Groups in shea butter and soap production were trained and provided with machinery (e.g. roaster and frying pans). As a result, shea butter that used to be produced only for domestic consumption is now produced in commercial quantities. Likewise, participants in shea butter groups now have the skills to add value to the shea butter by producing soap, which hitherto was not part of the livelihood portfolio of the community, but introduced at a workshop facilitated by resource persons hired by ACDEP and open to the group members. In addition, NGOs connected these groups with potential buyers of shea butter.

Table III-4: Livelihood diversification strategies of households in the previous year (N=127)

Diversification strategy	Organized/organic groups (n=79)	Non group (n=48)
Used improved crop varieties	61 (77.2%)	18 (37.5%)
Adapt planting dates	45 (56.9%)	10 (20.8%)
Adapt planting densities	45 (56.9%)	12 (25.0%)
Adapt pesticides/fertilizer application	57 (72.1%)	28 (58.3%)
Adapt tillage practices	26 (39.9%)	05 (10.4%)
Mixed cropping	70 (88.6%)	33 (68.7%)
Mulching	42 (53.1%)	08 (16.6%)
Stone bonding	23 (29.1%)	00 (00.0%)
Zero crop residue burning	68 (86.0%)	02 (12.6%)
Migratory fishing	12(15.1%)	00 (00.0%)
Trade in other goods	40 (50.6%)	06 (04.1%)
Processing of agricultural based products	17 (21.5%)	10 (20.8%)
Horticulture farming	49 (62.0%)	12 (25.0%)
Fuelwood trade	10 (22.7%)	00 (00.0%)
Change livestock composition	45 (56.9%)	11 (22.9%)

Source: Survey, 2017

The point made by horticulture, shea butter and soap production groups was that, acting collectively made it possible for them to access markets and meet market demands of buyers (quantities) and to bargain for competitive prices. Income earned from sales of products from these activities was re-invested in other livelihood activities or used for the purchase of food. A financial secretary of a shea butter and soap production group mentioned during a focus group discussion that: “last year our groups made a profit of GH¢1500.00 (USD$ 340.00) of which I took a loan of GH¢200.00 (USD$ 35.00) to buy improved maize seeds and fertilizer to farm that same year”. Similarly, a member of the horticulture group also mentioned that: “in the past we used to idle around without any work during the dry season but now we have something to earn income to buy food from the market when our crops fail due to drought”.

5.3.2. Organic groups formed by community members

The second types of groups that have emerged in response to climatic changes experienced in Bagri were those organically formed by community residents. About 22.0% of households in our survey held membership in these groups (see figure 4). Since the 2000s, there has been an increase in the formation of such groups around trade and migratory fishing in neighboring towns and villages in Burkina Faso and Ghana (see Figure III-1). Many of our respondents mentioned that these activities were undertaken as alternative sources of livelihood in response to diminishing agricultural yields mainly as a result of the negative impact of climate change and variability. Participation in the organic groups was voluntary and was largely determined by individual agency, age, skills, wealth, trust and reciprocity related to the notion of homophily. Like organized groups, participants in organic groups exhibited „degree centrality" and „betweenness centrality" as group activities such as trade and migratory fishing opened up new communication lines with individuals outside of their community. The major reason for people"s willingness/interest to form and participate in such organic groups was that, it was costly for them to engage in economic activities such as fishing and trading alone. In addition, being part of these groups and working together increased the market access and bargaining power of participants. For example, it was often mentioned by traders that external buyers of agricultural products were willing to pay higher prices when goods were sold in large quantities. Our household survey indicates that about 15.1% and 21.5% of households in groups engaged in migratory fishing and traded in agricultural goods respectively. Only 4.1% of non-group households engaged in trading of agricultural goods and none in migratory fishing (see Table III- 4).

Migratory fishing was mainly done during the dry season, between October and April in Dokyere, a village in the Wa-West district about 100 km away from Bagri (see Figure III-1). At the time of the fieldwork, eight different fisher groups, each consisting of about two to eight men have migrated to Dokyere to engage in fishing, a number which was mentioned to be more than double that of the 1980s and 1990s. Baba Ali, a hausa elder, mentioned that "in the past, only few people from this village travelled to Dokyere to fish and people rarely travelled to Zambo or Lawra, but now, many young men and women move to these places to either trade or to fish". It was observed that fishers in groups pooled resources in terms of skills and knowledge as well as capital assets (fishing gear such as nets, canoes etc.) when embarking on seasonal migration. The importance of resource pooling was exemplified by the fact that no individual fisher was observed to go on this type of migration alone. This was a point raised in many interviews, for example, Kamaldin, a group leader explained that "fishing gear is expensive and therefore it is impossible for an individual to own all fishing gear needed to embark on migratory fishing". The fishers furthermore argued that, migratory fishing was highly dangerous due to wild animals such as hippopotami in the Black Volta River. Therefore, groups provided security for all members in case of an attack. Diverse skills and knowledge were also held within fishing groups. For instance, while fishers from the Wangara ethnic group were experts in the construction and mending of canoes, those from the Hausa ethnic group were good at making fishing nets. Similarly, division of labor among fishers was also necessary in Dokyere, with different tasks shared among group members including setting of fish traps, processing fish (smoking) and selling fish in Wa and Kalaba (Figure III-1). As such, division of labor and the pooling of these varied skills fostered diversification beyond the abilities of individuals. In the view of Daniel a 42 year old Dagara man: "I used to be unemployed during the long dry season and as you are aware, it is the Hausa and the Wangara ethnic group that know how to fish and we the Dagara people only engaged mainly in crop farming. But because farming is no more profitable because of drought, many of us now have learned how to fish by joining Hausa people to Dokyere. I reinvest income from fishing into crop farming (fertilizer and hire tractor) and use some to buy food and pay schools fees of my children". Likewise, Rufai a 28 year old fisher

mentioned that "I earn between GH¢1000 and GH¢10,000 (USD$250-2500) depending on number of men, the quality of fishing gear in the group and available fish stock in a given year. I use the money from fishing to trade in livestock and farming".

Trade groups formed to facilitate access to agricultural commodities across networks with distant people, often, as far away as Burkina Faso. The groups made it possible to purchase cereals (rice, millet, sorghum and maize), and livestock (goat, cattle and sheep) from traders in Burkina Faso in order to sell these goods in urban centers in Ghana. Other essential items such as agricultural chemicals, alcoholic beverages and fuel (petrol and diesel), were in turn sold in Burkina Faso through the same networks. Fuelwood was another item traded in Ghana. Trading occurred year round but peaked during the dry season with men and women alike participating in this economic activity. Although, traders used their private capital, they acted as a group to negotiate for transport services at lower rates that enabled them travel to markets both near and distant. During focus discussions, traders mentioned that before the 2000s, when they embarked on trade as individuals, it was difficult to transport their goods because of the high costs of transportation. Transport operators only responded when traders were able to fill their trucks/lorries with goods and passengers. As a group, however, they negotiated with transport operators who came to Bagri on major market days (i.e. Wa and Zambo) to transport traders and their wares to and from these market centers. The cost of the transportation was shared among individuals within the group. Likewise, fuel wood traders were able to meet urban demands by collecting fuel wood as a group. For example, one fuel wood trader mentioned that: "the chop bars and boarding schools will only come to buy the fuelwood when we are able to provide them a truck load of fuel wood". As shown in our household survey results in Table III-4, only households in groups sold fuelwood (22.0%).

5.3.3. Collateral security and access to financial and material resources

Whether organized or organic, households in groups had more contacts with external institutions (e.g. private firms) than non-group households (see Table III-3). This was mainly because group membership was found to be a key requirement for accessing credits and other material support from NGOs, local government agencies, financial institutions and private firms (agricultural input dealers). Groups provided collateral security for credit. Operators of agricultural firms mentioned in interviews, for example, that granting improved seeds, fertilizers and pesticides as credits or loans to groups were less risky because, in the case of default by any one member, the entire group bears the cost. Indeed, there was no instance of these institutions lending money or providing agricultural input credits to individuals as observed during the fieldwork. Consequently, many of the households in these groups were members of the village savings schemes formed by ACDEP, a feature that made it possible for them to access loans to start new livelihood activities. Finally, these groups were able to leverage their collective strength to access credit at cheaper interest rates when approaching financial institutions. For example, during focus group discussions, the traders‟ group mentioned that they accessed loans from the Microfinance and Small Loans Center (MASLOC) at the Lawra District Assembly. This they mentioned could not have been possible had they accessed the loans individually as MASLOC provided such loan facilities to groups and not individuals. Kutumi, leader of the crop farmers association made this contribution during a focus group discussion: "at the beginning of the farming season, I will present the names of my group members together with the quantity of farm inputs needed by each of us to the woman that was introduced to us by ACDEP. We then pay 50% of the cost of the inputs in her account at the Lawra Rural Bank and then she will supply us the inputs. We then pay her the remaining balance after harvest".

5.4 Negative outcomes on community level social and ecological resilience

While the varied groups provided substantial resources for participating households regarding livelihood diversification and increased adaptive capacity to climate change, they were also observed to have some potential negative impacts on social and ecological resilience at the community level. The NGOs groups produced „winners and losers". Interviews with development workers and villagers indicate that, the process of selecting „worthy" beneficiaries is daunting. This was because most households were unwilling to disclose their „real" asset status in surveys for fear of exclusion from development projects. Development workers also noted that community leaders may not cooperate when they are excluded from a development project. This, they said contributed to the difficulty of identifying „worthy" households. The fieldwork revealed that the entire process of selecting „worthy" beneficiaries if not well managed had the potential of derailing social cohesion at the community level if not well managed. For example, Musah (46 years old) claimed he has never benefited from such development projects stating „when the projects arrive, it is the influential people in the community that gained and when you question them, they will say the computer did not select your name". Results from the survey showed that about 61.0% of respondents perceived community leaders as the main beneficiaries of external development interventions. In addition, some groups such as the VLSA required that members contributed weekly and, since most of the poor households were unable to do this, it resulted in their exclusion from such groups. Moreover, many NGOs preferred providing support to already existing and previously supported groups for the sake of continuity.

In addition, the introduction of new forms of livelihood diversification, notably, horticulture, shea butter and soap production might actually undermine future social and ecological resilience. Our respondents mentioned that, horticultural activities along the Black Volta River contributed to the depletion of vegetation cover along the river banks leading to contamination and silting of the river, which according to the fishers, greatly affected the availability of fish in the last three decade (Plate III-2). Likewise, shea butter and soap production, proved „self-defeating" as the producers depended on biomass (including shea trees) as fuels for the production of these products, which in turn, contributed to the depletion of the sources of raw material (i.e. shea nuts from shea trees). Groups that traded in fuel wood also contributed to the depletion of vegetation including shea trees. These activities were frequently mentioned in interviews by respondents as creating conflicts among resource users in the community. As such, the new livelihood diversification options facilitated by groups ensured new forms of resource exploitation that enhanced adaptive capacity. At the same time, these diversification strategies had the potential to undermine future ecological sustainability through conflicting group activities in the use of community natural resources and social cohesion through exclusion in the selection of beneficiaries into NGO led projects. This is mainly because there were no channels of communication between different groups in their use of community resources. The chief of Bagri, Naa Larepuo indicated during an interview that, there has been a rapid increase in the number of conflicts around resource use in the village, that require the mediation of his traditional court, especially between fishers and horticulture. He stated that: "The fishers have complained to me on several instances that horticultural activities pollute the river as a result of the dumping of waste materials from their plots into the river causing siltation and reduction in fish population. I always advise them to exercise patience as everybody is trying to look for his/her daily bread. I also told the vegetable farmers to move further away from the river to avoid pollution of the river".

Horticultural plots along the Black Volta River Stocking of fuelwood by traders to meet market demand

Plate III-2: Conflicting resource use exemplified by horticulture and fuelwood trade in Bagri

Source: Authors, 2017

6 Discussions

Social networks are generally accepted as being crucial for facilitating adaptation to climate change and variability (Adger, 2003; Rotberg, 2013; Rokenbauch and Sakdapolrak, 2017). The actual role that such social networks play in natural resource-dependent communities in developing countries faced with climate change and variability has not, however, yet fully been explored (Rokenbauch and Sakdapolrak, 2017). The aim of this study was to examine how organized and organic group activities foster livelihood diversification and resilience during climate change in a small rural community in northern Ghana. As in other studies in Sub-Sahara Africa (e.g. Osbahr et al, 2010; Adger, 2003; Goulden et al, 2013), our results clearly show that being part of organized and organic group activities do enhance adaptive capacity to climate variability through livelihood diversification and new farming techniques. Mainly, our results support findings in the literature that indicate how group activities enabled the sharing of information, materials, new knowledge and innovation that in turn facilitated the skills and resources needed to adapt to climate change (Moore and Westley, 2011; Nelson et al, 2007). Indeed, households participating in various group activities were shown to have clear adaptive advantages compared to households not partaking in such groups as they have more access to both material and non-material resources (See also, Adger, 2003; Berkes and Folkes, 1998).

In addition to providing much needed empirical evidence of the use and beneficial aspects of groups activities for climate change adaptation (Ireland and Thomalla, 2011; Rockenbauch and Sakdapolrak, 2017), our results indicate that the nature of group activities and the strength of social ties directly influence adaptation practices (Prell et al, 2009; Granovetter, 2005). Our results show how households engaged in organized and organic group activities enhanced livelihood diversification compared to non-group households. The two analyzed types of groups allowed the formation of social networks, with both strong and weak ties, with actors outside of the community. These strong and weak ties have different implication for livelihood diversification. Organic groups provided access to resource pooling and labor support compared to organized ones providing the new knowledge, innovation and information needed for livelihood diversification. The fact that our results align closely with previous research in this respect (Gong et al, 2017; Crona and Bodin, 2006; Prell et al, 2009; Newman and Dale, 2005 (Burt, 2004; Granovetter, 2005; 1975) indicates that adaptation initiatives that focus on the development of group activities or the use of existing social ties, would do well to consider whether the adaptation measure suggested is best suited a „strong" or „weak" ties. Our results show that the resources available, and needed, within the two types of groups are different. For example, organically formed groups such as migratory fishers and traders were only able to engage diversification by sharing and pooling material and non-material resources. On the contrary, organized groups supported new livelihood activities

such as the commercialization of shea butter and soap production and horticulture, which were all hitherto alien in the community.

Clearly, participation in group activities was crucial for adaptation options, but our results move this insight further by focusing also on connections between households participating in group activities and non-group households. The households in groups exhibited „degree centrality" which is understood as the number of networks stakeholders are directly connected to (Cassidy and Barnes, 2012), as well as „betweenness centrality" understood as the indirect connectivity or the bringing together of the disconnected segment of a network or whole networks by stakeholders (Wasserman and Faust, 1994; Bodin and Prell, 2006, Cassidy and Barnes, 2012). Our result indicates that, participation in group activities facilitated „degree centrality" and „betweenness centrality" or consolidation of and/or participation in other social networks. This was seen in the case of crop farmers" connection with agricultural extension officers, agricultural input dealers and weather information service providers (e.g. Essoko), that was mainly facilitated by NGOs. Indeed, research has shown that a high „degree centrality" and „betweenness centrality" enhances resilience by fostering social learning through mobilization of previously disconnected networks (Cassidy and Barnes, 2012; Newman and Dale, 2004). This is an important insight but our results cautions that participation in group activities is often defined by socio-economic factors, skills and trust factors that cannot easily be surmounted. Such factors may thus serve as barriers to connecting households or embedding new and often marginalized households in group activities. Adaptation projects focusing on establishing groups or drawing on already established groups should keep this in mind.

Another central aspect concerning group activities and social ties that was empirically evident in North West Ghana was the issue of homophily, i.e. a social selection process that describes the tendency for people to disproportionately form social ties with others similar to themselves (Barnes et al, 2016; Newman and Dale, 2007). Homophily is exemplified in our case study as social ties were formed mainly along occupational lines and the preferences of individuals, with fishing and horticulture being the clearest examples. This we identified to be problematic as the exchange of information and knowledge on natural resource use was limited by prevention of the flow of information between occupational groups in different networks. Examples of this can be found between fishers and horticultural growers, as well as, fuel wood traders and shea butter and soap producers in Bagri. Indeed, horticulture was mentioned as causing silting and the depletion of fish stocks in the Black Volta River. Likewise, fuelwood trade contributed to the depletion of vegetation cover including shea trees, the main source of shea nuts that were used in producing sheabutter and soap. As argued by Barnes et al. (2017), successful adaptation requires the integration and use of diverse knowledge in resource exploitation. Indeed, our case study highlights the need to promote knowledge exchange and communication among diverse stakeholders in different groups and social networks that depend on common pool resources within a particular community. A central point concerning collective activities is that, while overall they are beneficial, overly strong homophily may lead to maladaptation and prevent new and potentially better adaptation options from taking root.

Finally, the literature on the role of social networks in climate change adaptation and resilience has generally concentrated on their role in building adaptive capacity (Adger, 2003; Brown and Westway, 2011; Goulden et al, 2013; Rotberg, 2013; Rockenbauch and Sakdapolrak, 2017). Little attention has been paid to how group activities in turn can shift social and ecological system into future states of vulnerability. Thus, a key insight in our study is that, the positive impact of group activities on livelihood diversification can have future negative effects on both social and ecological resilience. The paper illuminates this point with examples that describes how group activities can derail ecological sustainability and social cohesion. Our results shows that group activities in shea butter and soap

production, fuelwood trade all influenced the depletion of vegetation and horticulture affected negatively water resources. In essence, all three activities severely undermined the ecological sustainability. Similarly, the results clearly outline how group formation and/or selection processes can undermine social cohesion by creating „winners and losers". For example, the selection of „worthy" beneficiaries in organized groups deepened marginalization of poor households and conflicts around resource use. The results indicate that non-inclusion in organized groups created resentment that could have implication for participation and cooperation that is necessary for community mobilization and social cohesion. Conflicting uses of resources, together with the observed lack of communication among different resource users had the potential of undermining future social cohesion. In fact, many of the studies on social networks pay little attention to social cohesion (e.g. Bodin and Crona, 2009; Barnes et al, 2016) but our results indicate that this is an important oversight and future research should aim to deepen our understanding on this issue. As amply illustrated in this paper, assessing the roles and benefits of group activities and social networks for adaptation to climate change in resource poor societies requires a holistic view of what group activities can do as well as what they might result in.

7 Conclusion

The results presented in this paper indicate that social networks and groups have an important role to play in the resilience of communities, not least in resource dependent communities facing climate variability and change. First, we assessed perception of climate change in our case study community over the last three decades. We found that the community studied is perceived by the respondents to have experienced climate change over the period. The perceived changes include decreasing precipitation, frequent occurrence of dry-spell events and rising temperature. These climate change events have negative impacts on agriculture in various ways including planning and decisions on farm preparation, sowing of seeds, and fertilizer and pesticide application all resulting in low agricultural yields. In response to this, group activities and social networks were formed. The group activities and networks fostered diversification that negated the impact of climate change and variability. Households in groups had diverse networks and livelihood strategies and were consequently more resilient because they had access to the critical resources (material and non-material) essential for diversification beyond the reach of individuals. The results presented in this paper highlight that, adaptation initiatives focusing on the development or use of existing groups and networks should consider whether the adaptation measure suggested is best suited to a „strong or „weak" network. The results further caution that socio-economic factors, skills and trust may serves as barriers for embedding new and often marginalized members in collective activities and networks. Our results also show that livelihood diversification strategies facilitated by different collective activities and social networks do have conflicting (maladaptive) outcome. Examples found in Bagri indicate that activities facilitated by networks such as shea butter and soap production, horticulture and the sale of fuelwood created conflicts in resources use among different stakeholders. As such this paper illuminates an important phenomenon that is often overlooked in the literature on the role of social networks in climate change adaptation. In summary, group activities and social networks create diverse pathways and outcomes for adaptive capacity and resilience in resource poor community such as Bagri. Therefore, fostering these activities and connections is a useful activity for NGOs and other institutions wanting to use groups and social networks to facilitate adaptation to climate change and variability.

Chapter IV

He who pays the piper calls the tune: understanding collaborative governance and climate change adaptation in northern Ghana

This is a manuscript of the following article: Dapilah, F., Nielsen, JØ., Lebek, K., & D'haen, SAL. He who pays the piper calls the tune: understanding collaborative governance and climate change adaptation in northern Ghana.

Fishers of Bagri making nets

Discussion session with opinion leader of Bagri

Abstract
Centralized state governance systems have been criticized for being ineffective and inefficient in tackling complex climate change challenges. Consequently, climate governance models that integrate collaboration among diverse stakeholders are seen as crucial in increasing adaptation efforts around the world. However, at present, there is little insight into the mechanics of collaborative adaptation governance (CAG) at the regional, national or global levels. Drawing on collaborative governance theory and literature on adaptation and sustainability, we use multiple qualitative research methods to explore CAG in northern Ghana. We examine the conceptualization and implementation of CAG projects as well the motivation behind them and their ensuing benefits. Results show that perceived climatic changes, diminishing agricultural livelihoods, adaptation resource needs and opportunities largely drive CAG. State actors and non-governmental organizations (NGOs) provide leadership in CAG, bridging gaps in access to adaptation resources through the provision of agricultural inputs, climate services, infrastructure and human capacity development. However, in parallel to these, there exist interwoven governance challenges that include questions of trust, commitment, transparency, accountability and the representation of diverse interests. We demonstrate how powerful state actors and NGOs set the agenda, frame problems, and implement rules and incentives that are contrary to the normative tenets of collaborative governance theory. Ultimately, the results of this study shows the failures, successes an sustainability challenges of CAG in northern Ghana, while also providing insight into the extent to which CAG approaches can facilitate adaptation to climate change globally.

1 Introduction

Climate change as a problem of collective action transcends multiple scales and crosses jurisdictional boundaries has spurred a myriad of governance challenges (Bäckstrand and Lövebrand, 2015; Brown et al., 2019; Intergovernmental Panel on Climate Change: IPCC, 2018; Jordan et al., 2018). Scholars and policy makers at the global and local levels are trying to understand, devise and set in motion new governance approaches that can help us adapt to climate change (Adger and Jordan, 2009; Bulkeley and Newell 2015; Meadowcroft, 2004; Pahl-Wostl, 2009). Indeed, the last decade has been an exponential growth in scholarship identifying and testing governance systems that are needed to facilitate adaptation to climate change (Bäckstrand et al., 2017; Biermann et al., 2012; Challies et al., 2019; Meadowcroft, 2007). Scholars, practitioners and policy decision-makers have turned towards governance approaches that increase participation and deliberation of multiple actors in collaborative governance arrangements across the private, government and civil society sectors (Bulkeley and Newell, 2015; Driessen et al., 2012; Emerson et al., 2012; Paterson, 2010). For example, numerous studies on climate governance have emphasized the role of local people and communities (Osbahr et al., 2010; Friis-Hansen, 2017; Rasmussen et al, 2018), businesses (Crick et al., 2018; Crawford and Seidel, 2013), government (Amundsen, 2010; Nalau et al., 2015) and NGOs (Nielsen et al., 2012; Friis-Hansen, 2017; Rasmussen et al, 2018).

CAG has emerged as a concept that encompass multi-organizational arrangement where a number of identified participants across public and private spheres (business and civil) work together to pursue shared purposes based on consensus and collective decision making (Emerson and Nabatchi, 2015; Ran and Qi, 2018).With the ratification of the Paris Agreement (Article 6, Number 8b), non-state actors (hereafter referred to as NSAs) are expected to play a crucial role in climate change governance decision-making, policy innovations and the implementation of adaptation strategies (Bäckstrand et al., 2017; Nasiritousi,2016; Pauw, 2017).

Yet, our understanding of why, how and under what conditions the participation of NSAs in climate governance aid adaptation, and how to track progress over time and across scales remains patchy (Emerson and Gerlak, 2014; Nasiritousi et al., 2016; Bäckstrand et al., 2017; Berrang-Ford et al., 2019). In particular, little empirical evidence available on developing countries (Brockhaus et al., 2012; Nasiritousi et al., 2016; Emerson et al, 2012). Existing studies on adaptation governance also largely focus on multi-level governance rather than on its collaborative aspects of it (e.g. D'haen and Nielsen, 2017; Nalau et al., 2015). The relational dynamics and processes between state actors and NSAs have received little attention especially in developing countries (Adger et al., 2005; Amundsen et al., 2010). Finally, there is a lack of knowledge regarding the involvement of private stakeholders and more generally on the actual interest of different actors in CAG processes (Gupta and Mason, 2016; Martin and Walters, 2013; Jacobs, 2013). Indeed, recent studies have shown that second order risks i.e. blame and threats to legitimacy that individuals (e.g. Political leaders) or organizations (governments or business) must manage in order maintain power and efficacy dominate how key actors take decisions and prioritize actions (Brown et al., 2019). In Ghana, where this study was undertaken, the existing literature highlights enormous governance challenges in the implementation of adaptation measures at both the national and sub-national levels, closely related to a lack of access to finance (Asante et al., 2015), institutional capacity and participation (Antwi-Agyei et al, 2017), as well as low levels of collaboration and coordination between governance structure across sectors and scales (UNDP, 2018).

Against this backdrop, we argue that it is important to shed light on the forms, functions and basis for CAG. More especially, we do not know the interests of NGOs and private sector firms in the conceptualization and implementation of adaptation measures as well as,

understanding better their relationship with state actors and local communities in the governance of climate change adaptation (Betsill, 2008; Jordan et al., 2018; Lemos and Agrawal, 2006). This is particularly relevant in developing countries where CAG processes are likely to play an important part in the implementation of their Nationally Determined Contribution (NDCs) under the Paris Agreement (UNFCC, 2015).

This paper explores CAG in the Upper West Region of northern Ghana, covering four districts (out of 11 districts) and one village. The paper is organized as follows. In section two, we present the theoretical perspective and focus on the interrelationship between collaborative governance and adaptive capacity in socio-ecological systems. This is followed by a description of the study setting and methods in section three. In section four, we present the results and cover the socio-economic, political and environmental context and two specific modes of CAG (state-led and NGO-network) implemented in the study area. Section five discusses the implications of our findings for CAG. Our conclusions follow in section six.

2 Theoretical and analytical framework

Collaborative governance is seen as „the processes and structures of public policy decision making and management that engage people constructively across the boundaries of the public government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished" (Emerson et al., 2012:3). It is based on a number of principles which include, but are not limited to, fair and civil discourse, as well as open and inclusive communication that is balanced by the perspectives and knowledge of all participants (Purdy, 2012; Blühdorn and Deflorian, 2019; O'Leary and Vrij, 2012; Emerson et al., 2012). The normative assumption is that, opening up the decision making to more inclusive, accountable, and transparent initiatives and measures makes it performance oriented in delivering more effective policy outcomes (Andonova, 2010; Ansell and Gash, 2008; Börzel and Risse, 2010; Driessen et al., 2012; Purdy, 2012; O'Leary and Vrij, 2012; Betsill, 2008).

Key variables that influence collaborative governance include the prior history of conflict or cooperation between stakeholders (Ansell and Gash, 2008), individual stakeholder incentives to participate (Andranovich 1995; Chrislip and Larson, 1994), power and resources imbalances (Emerson and Nabatchi, 2015; Huxham et al., 2000), and the leadership and institutional design (Agranoff, 2006; Bryson et al., 2006; Margerum, 2008). Factors for success identified by Ansell and Gash (2008) include the importance of face-to-face dialogue, trust building, and the development of commitment and shared understanding of the aims and scopes of processes.

Collaborative governance is purported by some researchers to be more agile and responsive to uncertainties and increasing levels of change than rigid state bureaucracies (Emerson et al., 2012; Pahl-Wostl, 2007). For example, Koontz et al. (2004) argue that „collaborative environmental management offers a flexible approach that can be molded into emerging views and knowledge". Therefore, collaborative governance approaches are seen as attractive in that they could enhance adaptation and adaptive capacities during climate change (Emerson et al., 2012; Rudnick et al., 2019). The IPCC defines adaptive capacity as the „ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities or to cope with the consequences" (IPCC, 2007:7). We argue that collaborative governance mechanisms are central determinants of adaptive capacity in socio-ecological systems (Fabricius et al., 2007; Folke et al., 2006; Nelson et al., 2007; Rudnick et al., 2019).

Firstly, the diversity and flexibility of institutional structures (formal and informal) in collaborative governance processes allows for learning and experimentation which are found to be essential for building adaptive capacity (Dow et al., 2013; Folke et al., 2006; Tompkins and Adger, 2006; Newman and Dale, 2005). The broader participation of various stakeholders at multiple scales can help reduce uncertainties and promote trust and knowledge sharing during policy implementation (Adger et al., 2009; Armitage and Plummer, 2012; Folke et al., 2005). Walker et al., (2006) and Walker and Salt (2006) note that in the Murray-Darling River Basin in Australia, landscape collaborative approaches that included formal and informal structures both within the catchment and the river basin were vital in solving significant governance challenges relating to hydrological changes.

Secondly, leadership is often identified as one of the key requirements for effective implementation of collaborative governance (Emerson et al., 2012; Evans et al., 2015; Fabricius et al., 2007) and for identifying and dealing with adaptation and in particular barriers to this (e.g. Moser and Ekstrom, 2010). Fabricius et al (2007:8) note that, communities that fail to adapt to disturbance events „lack the capacity for governance because of a lack of leadership, of vision, and information". Different leadership roles including that of a facilitator/mediator, convener, financier and advocate of a group have been identified in the adaptation literature (Agranoff, 2006; Bryson et al., 2006; Emerson and Gerlak, 2014; Gupta et al., 2010; Kates et al., 2012). However, it is generally argued that, diversity in the composition of leadership generate trust and legitimacy (Tompkins and Adger, 2004; Newman and Dale, 2005; Dow et al, 2013), and tends to be particularly important for managing conflicts (Gerlak and Heikkila, 2011). For example, diverse leadership was critical in the rezoning process of the Great Barrier Reef Park in Australia for which Olsson et al. (2008) acknowledge leadership to include senior scientists, environmental NGOs, and lobbyists from the tourism and fishing industries.

Thirdly, the literature on adaptation recognizes that, resources including human capital, financial resources, infrastructure, and technology are essential for building adaptive capacity (Adger et al., 2003; Nelson et al., 2007). Working in collaborative governance mechanisms creates the opportunity for new resources to be mobilized beyond what is available to any one participating actor (Emerson and Gerlak, 2014; Rudnick et al., 2019). Indeed, the deliberative and participatory process in collaborative governance promotes knowledge sharing and learning which is central to adaptive capacity (Armitage et al., 2012; Folke et al., 2005; Pahl-Wostl, 2019). For example, knowledge building and learning on a range of issues between different stakeholders was crucial in dealing with Acidification in Lake Racken (Sweden) (Folke et al., 2006; Olsson and Folke, 2001). In this paper, we posit that stakeholder engagement, a key enabler of the success and sustainability of CAG projects should be an iterative process at all levels of the adaptation planning process i.e. from scoping and design to implementation, monitoring and evaluation (Figure IV-1).

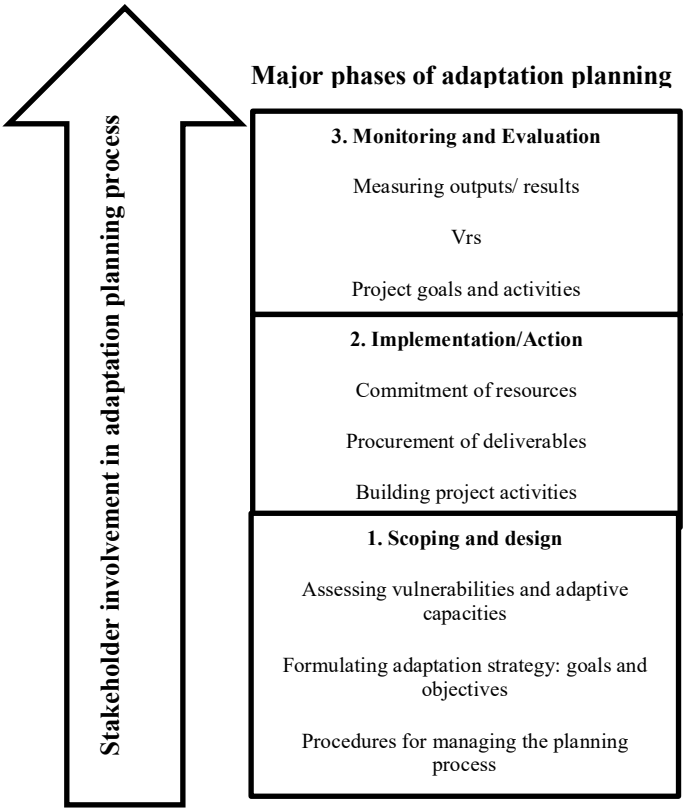

Figure IV-1: Conceptual framework
Source: Authors construct

Despite these obvious synergies between collaborative governance and adaptive capacity, the connections between the fields is, yet to receive sustained theoretical and empirical examination, particularly in developing countries (Bäckstrand et al., 2013; Meadowcroft, 2007; Bäckstrand and Löveland, 2015; Adger and Jordan, 2009). For example, the collaborative governance scholarship in SSA has not focused specifically on adaptive capacities per se, nor has it demonstrated that collaborative governance actually cultivates such capacities (Brochaus et al., 2012; D'haen and Nielsen, 2017; Rasmussen et al, 2018). Many questions regarding governance systems that facilitate or constrain the response of actors to climate uncertainties in such countries remain unanswered. Adding empirical insight to the literature on CAG is therefore useful on several fronts (Emerson and Gerlak, 2014; Emerson and Nabatchi, 2015; Hossu, 2018). In this paper we hope to articulate how CAG enhance adaptive capacity of stakeholders in northern Ghana during climate change. This is particularly the case since concerns regarding cross-scale governance and collaboration have been identified, including the question of how to facilitate collaboration between states and NSAs (Bäckstrand et al., 2013; Biermann et al., 2012; Challies et al., 2019; Nasiritousi et al., 2016), which is often a key aspect of this process in developing countries. Issues concerning the lack of inclusion and representation amongst stakeholders (Börzel and Risse, 2010; Blüdorn and Deflorian, 2019), a lack of transparency, accountability as well as access to project designs, methodologies and outcomes have similarly been highlighted elsewhere the literature (Martin and Walters, 2013; Gupta and Mason, 2015; Jacobs, 2013). We will turn to these issues.

3 Study area and methods

3.1 Study area

The study was undertaken in four districts and one village in the Upper West Region of Ghana and covers state and non-state institutions (Figure IV-2). The region is one of the least developed in the country and this is reflected in the socio-economic status of the population (Ghana statistical Service: GSS, 2012). There exist high levels of poverty and a majority of residents of the region are engaged in subsistence agriculture (Ghana Statistical Service, 2012; UNDP, 2018). The region falls within the Guinea Savanna zone, an ecological zone suitable for crop and livestock production. The zone is dominated by grasses, shrubs and scattered drought-resistant trees such as shea, baobab, locust bean and ebony. In terms of climate, the zone experiences two main distinct regimes, dry and wet seasons. About 90% of precipitation occurs within the wet season between April/May and October, with average annual rainfall amounts of about 900-1100mm. Temperatures in the wet season range between 25˚C and 36˚C during the day. The dry season starts in October and end in March. During this period, temperatures range from a low of 15˚C at night to a high of 42˚C during the day. Dry season temperatures have great influence on soil texture and composition, and vegetation cover (tree and grasses). These features of the vegetation are in turn exacerbated by human activities such as dry season bush-burning. Other environmental conditions experienced in the ecological zone include droughts, floods, windstorms, intense dust and heat conditions, and creeping desertification (MESTI, 2013). The characteristics of the Guinea Savanna ecological zone makes agricultural livelihoods vulnerable to climate change (Serdeczny et al., 2016). Available data on past rainfall and temperature patterns as well as projections for the future in climate models are diverse and uncertain (Amlalo and Oppong-Boadi, 2015). However, there is considerable consensus that there is likely to be a reduction in rainfall and an increase in temperatures in the future (see Table IV-1).

Table IV-1: Scenarios of Mean annual change in rainfall and temperature for Guinea Savanna zone

Year	Rainfall(mm)	Temperature(˚C)
2020	-1.9	0.8
2050	-7.8	2.5
2080	-12.8	5.4

Source: Minia, 2004; UNEP/UNDP, 2009

Bagri, our case village is located in the Lawra District and lies approximately on latitude 10˚43′ north and longitude 2˚53′ west, about 15 km away from Lawra town. Bagri consists of 198 households and has a population of 1,040 (Male: 514, Female: 526) (GSS, 2012). The socio-economic trend in the Upper West Region (including the four study districts) mirrors that of Bagri. The economy of the village is subsistence based with crop production being the dominant economic activity. Other important livelihood activities include livestock and poultry (73.2%), fishing (49.6%) and trade (47.2%). The village has only a basic school built by the Baptist Church in 2014 and the majority of household heads are illiterates (82.6%). Access to basic infrastructure to support economic activities is also highly inadequate.

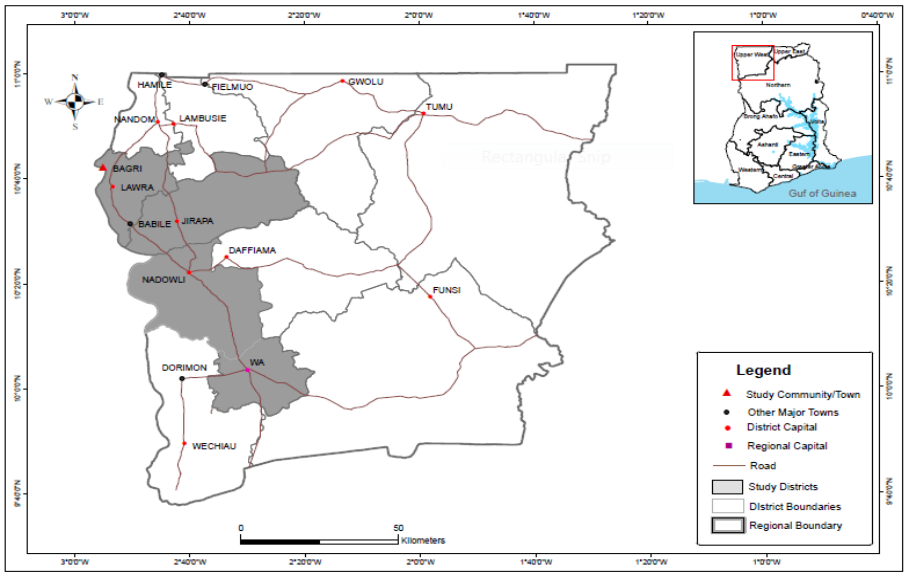

Figure IV-2: Map showing the study context

There is no electricity and the village lacks transport services and key facilities for agricultural storage, equipment (e.g. tractors, silos) and irrigation such as dams. The single rainfall season and the lack of irrigations facilities means that farming is limited to only one cropping season between April and October. Moreover, the length of the crop season is perceived to have declined over the last three decades, limiting crop production to only those crops that have short life-cycle (Dapilah et al, 2019; Yaro et al, 2016). The low socio-economic status of the villagers coupled with diminishing agricultural yields over the last three decades creates food insecurity, especially during the long dry season. Climate data obtained from the Ghana Meteorological Agency weather stations in Babile, the nearest to Bagri (about 25km), do in fact confirm a declining annual rainfall and increasing mean temperatures in the last five decades (Figures IV-3 and III-4).

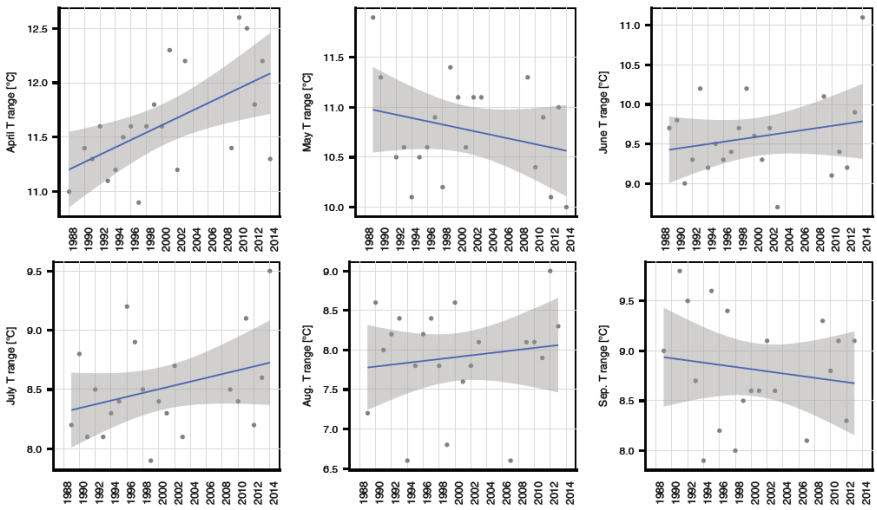

Figure IV-3: Wet season monthly temperature range for Babile weather station (1988-2014)

NB: The grey dots represent the data points. The blue trend line results from linear regression. The shaded area represents the confidence interval of the linear regression. The increasing trend in April is significant (Spearman"s rank correlation test, $p = 0.014$). There are no significant trends from May to September ($p > 0.05$).

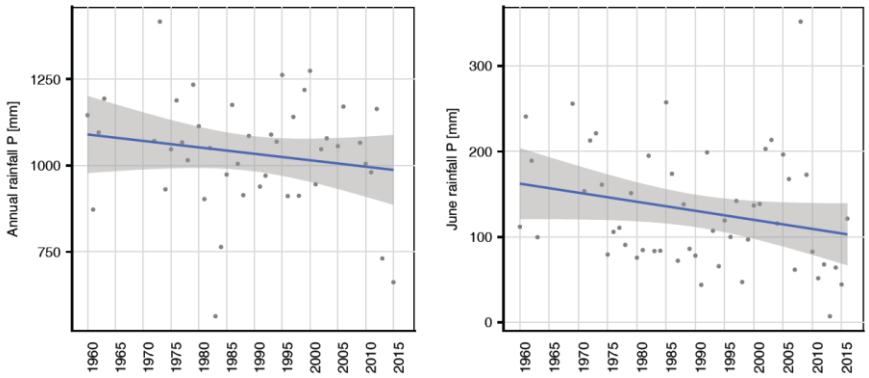

Figure IV- 4: Rainfall records for Babile weather station (19960-2015)

NB: The grey dots represent the data points. The blue trend line results from linear regression. The shaded area represents the confidence interval of the linear regression. The annual decreasing trend for the period is insignificant. The decreasing trend for the month of June is significant (p = 0.0322, Spearman's rank correlation

3.2. Methods

The study was carried out between February and July 2017. During this period, the first author lived in Wa, Lawra and Bagri. Data was collected using multiple qualitative research methods with key stakeholders involving both state and NSAs (see Table IV-1). We defined state actors as civil servants working in local government institutions that operate under the decentralized governance structure in Ghana. The category NSAs included local NGOs, private sector actors and local communities/society (our study village Bagri). NGOs refer to local and non-profit organizations. Private sector actors were defined as business firms and entities established for profit.

In Bagri, semi-structured interviews (n=64) were conducted with key subjects including village leaders such as the chief and queen mother, earth priest, sectional and ethnic leaders and ordinary men and women in the village. The goal of these interviews was to obtain a representative sample that covered socio-economic, age, gender diversity roles and governance in the village. Interview questions covered different aspects of respondents‟ general life such as family composition and relations, living conditions, and occupations. A main aspect of the interviews aimed at eliciting participants‟ local ecological knowledge on climate change and variability and how/if this affected their livelihoods. If the respondent‟s livelihood was affected, the study aimed to discover they navigated these effects by, for example, pursuing different livelihood strategies. The questions also aimed at an in-depth understanding of how our respondents and the community in general have worked with external organizations, state and NSAs in climate change adaptation project in the village. This enabled us to unearth key drivers of collaborative processes, roles and responsibilities of stakeholders‟ in the conception, design, and execution/implementation of both past and ongoing adaptation projects. This helped us to understand the successes and failures of these projects in the village. Focus group discussions (n=22) were conducted with men (n=10), women (n=8) and both men and women (n=4) across different socio-economic backgrounds (e.g. ethnicity, occupation and gender). Each discussion consisted of 6 to 12 participants. Focus group discussions lasted between one and two hours. Selecting participants with different socio-economic backgrounds provided the opportunity to capture diverse dimensions, the complexity of climate change and livelihood challenges in the village and

how different adaptation projects were shaping livelihoods. This allowed us to corroborate and substantiate themes that emerged in the semi-structured interviews.

Participant observation and cross-sectional walks led by young men in the village were chosen to facilitate rapport with residents of the community being studied. The constant presence of the first author in the village not only allowed observations of villagers" adaptation strategies to climate change but also of the daily activities and adaptation projects ongoing in the village.
127 questionnaire interviews were undertaken with household heads (out of 198 households). Households were defined as a group of people who owned the same resources, lived together and were fed from the same pot (Ghana Statistical Service, 2012; Yaro, 2013). Households were stratified to cover the socio-economic groupings (e.g. ethnicity, occupation and assets) in the community. The survey was semi-structured and captured household socio-economic characteristics, perception of climate change and impacts over the last thirty (30) years and the dominant livelihood diversification strategies employed by households and household contact with external agencies and their role in shaping adaptation to climate change.
Following the basic insight from the village level, and in order to better understand the extent to which climate change is perceived as a problem and accordingly influences how different actors collaborate, we conducted semi-structured interviews (n=14) with key actors involved in a range adaptation projects across the Lawra district and three adjacent districts (see Figure 2). We aimed at covering a broad range of actors engaged in different aspects of adaptation projects such as research and innovation, capacity building, or the provision of infrastructure and services for adaptation. Interviewees, including development planning officials, NGO project staff, meteorologists, agricultural extension officers and business managers, were sampled using snowball sampling. Interviewees were asked about the nature of their collaboration with other actors, including drivers and motives for collaboration, past and existing collaborative arrangement and how such arrangements were shaping adaptation to climate change and variability. The duration of the semi-structured interviews was about 40-60 minutes and the focus group discussions usually lasted between one and two hours.

All interviews and discussions were conducted in Dagaare and Hausa (with the help of an interpreter) or in English when the interviewee or interviewees were sufficiently fluent. Interviews and focus group discussions were recorded and transcribed. Observations and informal conversations were written down in field notebooks and subsequently coded into themes for analysis. Data from questionnaire surveys were coded and inputted into SPSS version 20 and cross tabulation and analysis of different variables and interpretation of frequencies was carried-out and then processed into tables, graphs and percentages. Content analysis of qualitative data was done, which revealed patterns and themes in interviews, as well as discussions to be derived and interpreted.

Table IV-2: Actors, spatial scale, methods and number of respondents

State actors	Location	Method	Respondents	Number
District Assembly	Wa, Jirapa, Nadowli-Kaleo	Interviews	Planning Officer	3
Savanna Agricultural Research Institute	Wa	Interviews	Agricultural Economist	1
Ghana Meteorological Agency	Wa	Interviews	Meteorologist	1
Ministry of Food and Agriculture	Lawra, Wa	Interviews	Agricultural Expert	3
Environmental Protection Agency	Wa	Interviews	Environmental Officer	1
NSAs				
NGOs				
ACDEP	Wa-operate in four districts	Interviews	Project Field Officer	1
Pro-Net North	Wa-work in all four	Interviews	Programmes Officer	1
IFDC	Wa	Interviews	Programmes Officer	1
Business				
ANTIKA Enterprise	Wa	Interviews	Chief Executive Officer	1
HAMIDA Enterprise	Lawra	Interviews	Chief Executive Officer	1
Community				
Bagri	Lawra		People of Bagri	
		Interviews	Men-40 and Women-24	64
		Discussion	Men -10; Women-8; Men and Women-4	22
		Conversation	Presence in Bagri	
		Observation	Presence in Bagri	
		Survey	Household heads	127 out of 198

4 Results

4.1 Increasing climate variability and diminishing agricultural livelihoods.

The perception of both formal experts and residents of Bagri is that climate change and variability has been happening in the region over the last three decades. Our respondents observed a decline in rainfall and the length of the rainy season as well as an increasingly late onset and early cessation of rains. Climate extremes including prolonged droughts, dry spells, heavy rainfall, floods and rising temperatures as well as the increasing frequency of windstorm events since the late 1990s and early 2000s, also figured heavily in interviews and surveys. For example, in the household survey, about 86.6% of household heads in Bagri believed that annual precipitation had decreased over the last three decades. Since the year 2000, Bagri has experienced five main floods (in 2000, 2004, 2010, 2014 and 2018) related to intensified rain storm events. In relation to temperatures, 88.1% of respondents suggested that dry season and rainy season temperatures had increased while 69.2% stated that rainy season had increased. About 87.4% of respondent claimed that the intensity of dry season winds had increased while 43.4% stated that winds in the wet season had also intensified. These changes were mentioned as having had a negative toll on agricultural productivity. When discussing the effects of climate change, interviewees reported that increasingly crops are being swallowed by floods, top-soils are being washed away by heavy rainfall events, drought is causing crop withering, excessive temperatures are causing high evapotranspiration, loss of soil moisture, strong winds that break maize and millet stalks. In fact, adaptation strategies such as the use of improved crop varieties, fertilizer and pesticides were reported as also having been affected by climate extremes that lead to lower crop yields and the financial indebtedness of households (See Dapilah and Nielsen 2019).

4.2 Low access to resources triggers the need for collaborative adaptation governance

The changing climate experienced in the region has resulted in the need to adapt. However, respondents felt that the material and non-material resources needed to adapt were beyond the reach of households or individuals and were also unattainable by many of the decentralized state institutions responsible for climate change adaptation. Indeed, the lack of resources such as infrastructure, access to climate information and services, and financial and human resources was a common issue raised by our respondents. One expert at the Nadowli-Kaleo District Assembly Mr.Bimi highlighted the latter: „the Assembly has not received subventions from government in the last eight months, grinding planned activities to a halt because there is no money to even fuel motorbikes needed to run extension services for farmers". NGO project officers interviewed echoed this claim, explaining that projects often only come with „skeletal staff". In addition, the NGOs lacked experts in climate change adaptation to facilitate the implementation of their projects. The concerns of businesses were similar. Many business owners claimed that, they lacked markets for their products as well as financial resources and technology to go into large-scale production of agricultural inputs.

In Bagri, the socio-economic status of most households was generally low with many respondents mentioning that they lacked access to fertilizer and pesticides, improved seed varieties, climate services and information and knowledge on agricultural adaptation practices. The lack of adaptation resources in our four districts and Bagri village has triggered CAG initiatives and projects. Respondents believed that these initiatives enhance access to resources through interdependence among the participating stakeholders as well as through facilitating a better distribution of actually available resources for adaptation. NGOs, businesses, district-level civil servants and local residents have consequently engaged in various collaborative projects which we divide into two different categories i.e. state-led and NGO-network CAG (Table IV-3), depending on whether they were initiated by state institutions or NGOs.

4.3.1 State-led collaborative adaptation governance

We classified state-led CAG as actions where civil servants identified adaptation needs and problems of communities, as well as designed and implemented modalities or measures for adaptation. State-led adaptation projects often had goals that were in line with and defined by (international) funder objectives (e.g. World Bank). As a result, civil servants identified the adaptation needs and problems of communities and designed adaptation interventions in tandem with funder objectives. Decisions on adaptation project conceptualization were top-down and unilateral and involved little or no input from participating private sector firms and local communities. Often, it is only at the implementation stages of state-led adaptation projects that civil servants invited the input of local communities that benefited and private sector firms to seek their inputs. Participation of local communities in the implementation of state-led adaptation projects was achieved by civil servants through two main modalities. The first modality was „subtly enticing" local communities through incentives, for example, labour wages, and financial and material resources for adaptation projects. A second approach taken by civil servants involved demanding a commitment of resources (financial and non-financial) from local communities prior to the implementation of adaptation projects. Local communities that met these resource demands often became beneficiaries of state-led adaptations projects.

A common belief of many civil servants interviewed was that this approach facilitated the mobilization of additional resources that supported project implementation and ignited commitment and ownership of projects by local communities leading to their overall sustainability. Private businesses participated in state-led adaptation projects through legal contracts for the provision of infrastructure and services. Often, their involvement was initiated by inviting them to state-led workshops where the rules governing the project were communicated and tasks and responsibilities were assigned to stakeholders by civil servants. Surprisingly, despite the fact that NGOs had major stakes in climate change adaptation in the study area, they were not invited by civil servants to take part in the planning or implementation of any of the state-led adaptations projects that were part of this study.

The CREW project[1] implemented in Bagri in 2014 by the Lawra District Assembly in collaboration with the people of Bagri and Bunas enterprise, a private construction firm is one example of a state-led project. The project was conceived in response to the 2014 floods in Bagri. According to state officials, the goal of CREW was in line with Ghana"s plan of action for disaster risk reduction and climate change adaptation under the Hygo Framework for Action (2005 - 2015). The framework aimed to build capacities that would reduce disaster risk by putting in place integrated early warning systems. An early warning communication system was procured and installed at the District Office to provide flood and drought forecasts. Based on ex ante estimates, state officials believed that, together with the construction of an irrigation facility in Bagri, this would alleviate flooding risks increasingly experienced in Bagri. Crops previously planted along the banks of the Black Volta River could for example, be moved further inland in the irrigation fields that would be constructed. The approaches used in the conception, design and implementation of CREW were also identified in other state-led adaptation projects. Three different afforestation projects (see Table IV-3) implemented by the Lawra District Assembly in Bagri over the last decade followed the same procedure.

1 https://www.gh.undp.org/content/ghana/en/home/operations/projects/environment_and_energy/crew.html

Table IV-3: Examples of state and network collaborative adaptation governance projects in the study context

Name of Project	Project Goal/activities	Duration	CAG mode	Location	Lead /funding Organizations
*Savannah Accelerated Development Authority (SADA) afforestation project	-Afforestation	2012-2016	State-led	All four districts	Lawra District Assembly/Government of Ghana
*Sustainable Land and Water Management (SLWM)	-Soil management and Afforestation -Education on land degradation	2004-2016	State-led	Lawra	Ghana Environmental protection Agency/GEF
*Resilient and Sustainable Livelihood Transformation (RESULT)	-Increased, diversified and more equitable agricultural production - Increased, diversified and more equitable assets and income	2012-2018	NGO-network	-Lawra/Bagri -Jirapa	ACDEP/ USAID
Agricultural Development and Value Chain Enhancement (ADVANCE)	- Agricultural Development -Value Chain Enhancement	2014-2018	NGO-network	Lawra/Bagri	ACDEP/USAID
*Community resilience through early warning (CREW)	-Training on community early warning systems to floods - Construction of Irrigation facility	2013-2017	State-led	Lawra/Bagri	NADMO/Lawra District Assembly/UNDP/ Norwegian Government
Agriculture Technology Transfer project	-Increase the availability and use of agricultural technologies -Maximize and sustain agricultural productivity	2013-2018	NGO-network	Wa	IFDC/USAID
Climate Resilient Agriculture and Food System	-Livelihood diversification - Capacity developments	2011-2014	NGO-network	Nadowli-Kaleo	ProNet North/OXFAM
*Ghana Social Opportunities project	-Provision of infrastructure -Reclamation of degraded land	2010-2018	State-led	All four districts	Lawra District Assembly/World Bank
Climate change adaptation platform	Platform for knowledge exchange on climate change adaptation	2014-2016	NGO-network	Lawra, Jirapa	CARE International
Climate services and participatory scenario planning	-Knowledge exchange in climate forecast	2011-2017	NGO-Network	Nadowli-Kaleo	CARE International

The Ghana Social Opportunities Project (GSOP), for example, was initiated in 2014 focused on afforestation covering five hectares of degraded land in Bagri. State officials envisioned that this would provide labour-intensive employment and wages for the villagers that could be used to purchase food and farm inputs in order to adapt to diminishing agricultural yields, climate change and variability. The planted trees would restore degraded lands and help stop climate change in the village. As in the example of CREW, the Lawra District Assembly collaborated with various stakeholder groups including the villagers. Concretely, the project was formulated at the Lawra District Assembly and subsequently communicated in a series of workshops taking place in Bagri. In these workshops, fields in the village in which trees were to be planted were jointly identified by state officials and village leaders. Other project-related issues regarding the selection of beneficiaries, schedule of activities, working hours and wages were further communicated to the villagers at these workshops.

4.3.2. NGO-network collaborative adaptation governance

NGO-network CAG in this study is defined as adaptation actions that are jointly undertaken by state actors, NGOs, private sector business and local communities. The distinctive features of this type of adaptation governance include networking among all participating actors, emphasizing the principles of non-hierarchical alliances and consensus-oriented decision-making processes. The ultimate aim was to achieve an interactive process that seek multiple perspectives and joint analysis of adaptation challenges as well as how to implement plans and actions. Empirically, the lead NGO forms networks of collaborators that involve state actors and NSAs in order to implement a certain predefined adaptation measure. It was believed by NGO officials that networks of diverse actors promoted interdependence and an efficient way of utilizing and coordinating scarce available resources among participating actors. Additionally, it was seen as a means of attaining project sustainability, a point echoed by Samuel, a Project Officer of the International Fertilizer Development Center (IFDC): „we lack staff and expertise on climate change adaptation that is why we collaborate with other local partners and network resources among them so that they can continue to work together when our project folds-up".

The Resilient and Sustainable Livelihood Transformation (RESULT)[2] project is an example of a network-led CAG project initiated in northern Ghana in 2012 and implemented in Bagri in 2014 by the Association of Church-Based Development Projects (ACDEP), a local NGO. The overarching aim of RESULT included integrating food security and sustainable livelihood interventions that increase adaptation to climate change and reduced vulnerability to disasters. To achieve this, ACDEP had predetermined sets of project interventions packages that included crop and livestock farming, dry season horticulture, village savings and loans schemes (VSLA), and the provision of climate services and information. ACDEP used surveys on vulnerability to climate change and poverty indicators to identify beneficiary communities as well as individual participants. Through flexible processes that involved deliberations in a number of meetings and workshops, ACDEP allowed participants to freely choose from their packages of interventions after which they were organized into groups and assisted in selecting their leaders democratically. The groups were then networked with state actors such as agricultural experts drawn from the Lawra District Assembly and Essoko, a business that specializes in climate services, and Hamida enterprise a business specializes in agricultural inputs and marketing. The various groups were additionally supported with various adaptation resources (e.g. extension services) free of charge for onward implementation.

[2] http://acdep.org/new/index.php/programmes-projects/agriculture/resilient-sustainablelivelihoods-transformation-project-result)

4.3. Benefits of collaborative adaptation governance

4.3.1. Access to adaptation resources

Participants in both types of CAG accessed material and non-material resources needed for climate change adaptation. Regarding material resources, IFDC provided the regional office of the Ministry of Food and Agriculture (MoFA) in Wa with an agricultural seed production laboratory, motcycles and financial resources to support the implementation and monitoring of their projects in the region. Likewise, through counterpart funding between NGOs and private businesses in CAG, agricultural equipment and technologies were acquired and made available to smallholder farmers. A seed laboratory was jointly funded by IFDC and Antika enterprise (fifty-fifty cost sharing). The laboratory facilitated the testing and production of improved maize seed varieties suitable for adaptation to climate change. IFDC made these improved seeds available to beneficiary smallholder farmers participating in their projects through gifts and subsidies (Plate IV-1). In Bagri, the various CAG projects between the villagers, state actors and NGOs facilitated access to several adaption resources including tree seedlings, free and subsidized fertilizers and improved seeds, climate services and agricultural information, improved livestock breeds, financial schemes and labour wages (Plate IV-1).

Maize shelling machine acquired by Hamida and ADVANCE through counterpart funding

Beneficiaries of livestock under the ACDEP project in Bagri

Seed Laboratory funded by Antika/IFDC in Wa

Improved maize varieties produced by Antika Enterprise

Plate IV-1: Benefits of collaborative adaptation governance

Source: Authors, 2019

4.3.1 Knowledge exchange, learning and capacity building for adaptation

CAG facilitated a better flow of information and increased interaction, learning and experimentation among state actors and NSAs which up to this point had not been common in the study area. The IFDC collaboration with Antika around the establishment of the agricultural seed laboratory by Antika and IFDC, for example, deepened collaboration

between SARI and MoFA in the provision of technical support and breeder seeds. It also led to the provision of certification and licensing and facilitated the production of improved seed varieties by Antika enterprise. ACDEP facilitated the networking relationship between two private firms, Essoko and Hamida enterprise which aided smallholder farmers‟ access to agricultural inputs and free climate and market information that was essential for adaptation decision making.

Moreover, CAG built the adaptive capacity of various stakeholders including state and NSAs. The manager of Antika enterprise was trained in Tanzania on how to operate the seed laboratory with the cost borne by IFDC. The capacities of several agricultural experts were enhanced at workshops organized by NGOs which they subsequently imparted to smallholder farmers. Agricultural experts and farmers exchanged knowledge on various farming techniques that were well suited to adapting to climate change on agricultural demonstration fields that had been established by ACDEP in Bagri. These included techniques such as composting, minimal tilling, ridging and stone bonding, all essential for soil conservation and flood prevention. In Lawra and Jirapa districts, the climate change platforms of CARE International allowed deliberation and information sharing among experts and local communities and the drawing of plans and formulation of by-laws, such as the passing of the bush-burning by-law in Lawra District in 2015.

4.4 Problems and challenges of collaborative adaptation governance

4.4.1 Participation, transparency, trust and accountability challenges

The failures of the two types of CAG are related to complex interwoven governance challenges including, how to facilitate participation in decision making and how to take the concerns of villagers and other stakeholders equally into account, even when these concerns diverged widely. The latter was clearly exemplified in CREW, where villagers wanted resettlement packages in the form of new houses rather than the construction of an irrigation facility. In general, according the villagers interviewed on this matter, project goals did not reflect the immediate adaptation needs of the community. Indeed, the state did not explore any avenues for CAG negotiation by the villagers as the projects goals were in all cases predefined by the Lawra District Assembly. Naa Laaripuo, Chief of Bagri, for example, speaking on the GSOP afforestation project mentioned that: „we preferred that the District Assembly provided us with electricity, or tractor and fertilizer. But they rather told us to plant trees because it will bring us rains‟. Likewise, Mariama, a 34-year old woman discussant and participant in the SADA afforestation project mentioned that: „the project supervisors all came from the District Assembly in Lawra town, to give us our daily task on the field. No supervisor was selected from this village. Sometimes, we will wait for them all day on the field and they fail to turn up‟.

In fact, none of the state CAG projects actually worked, beyond their project identification and formulation (see Plate IV-2). Moreover, the villagers also mentioned that, the Lawra District Assembly had deprived them of many projects through corrupt practices. This created mistrust which was not helped by the fact that interviewees felt that the Assembly had failed to honor several promises of development interventions including climate change adaptation projects. One male focus group around issues concerning trust in the CREW project formulated their experiences as follows: „when the floods occurred in 2014, state officials together with some “white men” came and held meeting with us. In that meeting, it was agreed they would assist us to build new houses so we can relocate away from the banks of the Black Volta River. Surprisingly, some few weeks later, state officials came to tell us that they have decided to construct an irrigation site for the community instead of the houses‟.

CREW project in Bagri

Failed CREW irrigation site under lock

Estimated employment under GSOP afforestation project in Bagri

Burnt SLWM afforestation site due to lack of care

Plate IV-2: Examples of failed CAG projects in Bagri

Source: Authors, 2019

Likewise, in the GSOP afforestation project, the signpost erected in the village indicates that the project would employ about 1,939 people in Bagri. However, it was claimed by respondents that only 50 people benefited, further deepening mistrust and leading to commitment problems. Discussions about the size of the irrigation site provide another example of the lack trust, commitments and accountability between collaborators in the project. This facility was to cover 45 acres of land but the land area set aside and fenced was far smaller, a point emphasized by female discussants that were to work this land.

4.4.2 Lack of coordination and alignment across state and network CAG

Problems concerning fragmentation and duplication of CAG projects were highlighted by our respondents. The absence of adaptation policies and strategies or systems to track adaptation measures across temporal and spatial scales loomed large in the study region. Indeed, stakeholders who wanted to, or were already implementing adaptation measures lacked information on what adaptation measures other actors were implementing across sectors, spatial and temporal scales. Differences in the funding schemes, time lines and objectives of the various adaptation projects made coordination and alignment with local development plans difficult. Indeed, according to our respondents, synergizing state-led and NGO-network CAG difficult due to the diverse interests and funding structures of stakeholders (e.g. between OXFAM and USAID). In the words of one Development Planning Officer of the Jirapa District Assembly: „our medium-term development plan covers climate change adaptation. However, we are unable to harmonize it with that of the NGOs working in our district because they have their own funding and we cannot impose our adaptation plans on them". 4.4.3 Funding challenges: what happens when the well runs dry?

Funding modalities of CAG projects often operated on short time scales of between two and five years. Indeed, as envisioned by NGOs and state officials, CAG did not necessarily facilitate sustainability and many projects did not exceed beyond their initial funding period.

For example, Essoko and Hamida stopped providing free climate services and subsidized agricultural inputs to beneficiaries when the ACDEP project ended. In the three afforestation projects, beneficiaries stopped working on the fields when wages were not paid. The participatory climate forecast scenario and workshops and meetings that were held among stakeholders in Nadowli-Kaleo and Lawra districts, respectively were not maintained due to the lack of funding needed to organize and pay wages of participants. Private businesses such as Antika and Hamida enterprises only provided their services in CAG on the condition that they would profit, withdrawing as soon as this was no longer the case. Hence, the connection between CAG and the sustainability of adaptation measures as viewed by state actors and NGOs did not actually work. The lack of continued funding and the dominance of private interests were crucial in this regard.

5 Discussion

Over the last 50 years, climate change and variability have been experienced widely in SSA (Niang et al., 2014; Roudier et al, 2011; Schlenker and Lobell, 2010) . This has occurred in the context of high levels of poverty (Tschakert and Dietrich, 2010), unstable political institutions and states (World Bank, 2014), diverse socio-cultural contexts (Jones and Boyd, 2011), poor market access and a general lack of institutional and infrastructural support. When combined, these factors have made adaptation to climate in this region highly challenging (Connolly-Boutin and Smit 2016; IPCC 2014). Utilizing the few resources available and coordinating different needs, initiatives and projects, have therefore, become a matter of concern (Antwi-Agyei et al, 2017, UNDP, 2018). The need for better governance is both urgent and important.

Climate change governance involves a complex of state and NSAs across multiple scales, jurisdictions, and policy domains (Bulkeley and Newell, 2015; Bäckstrand and Lövebrand, 2015). Environmental governance structures have expanded in response to such complexity, from hierarchical approaches to bottom-up, collaborative arrangements that incorporate not just only participatory approaches but also those of equity, legitimacy, transparency and accountability (Lemos et al., 2013; Okereke et al., 2009; Okereke et al, Martin and Walters, 2013; Gupta and Mason, 2015, Morrison et al, 2019). CAG, understood to be a multi-organizational arrangement where diverse participants across public and private spheres work together based on consensus and collective decision making to pursue shared purposes is one such structure. CAG approaches are regarded as attractive in that they could enhance adaptation and adaptive capacity through better leveraging resources for adaptation (Tompkins and Adger, 2004; Emerson et al, 2012; Rudnick et al., 2019) but also through inclusion and participation, legitimacy, accountability, trust and commitments between project stakeholders (Driessen et al, 2012; Ansell and Gash, 2008; Emerson and Gerlak, 2015).

Yet, the literature on CAGs in SSA, and elsewhere remains sketchy (Okereke et al, 2014; Emerson et al, 2012; Lemos and Agrawal, 2006). Indeed, despite the increasing attention to collaborative engagements in global arenas (IPCC, 2018; Brown et al, 2019), we know little about whether CAG leads to successful adaptation to climate change and variability at the local level. This paper has added to this literature by exploring why, how and under what conditions CAG are initiated/designed and implemented in order to adapt to climate change in northern Ghana. It has also shed light on the effectiveness and sustainability of CAG as well as its successes or failures.

Previous studies have shown that incentives and interests closely related the lack of and/or access to material and non-material resources are important in initiating collaborative environmental governance (Andranovich, 1995; Chrislip and Larson, 1994). Our results

indicate that general socio-economic deprivation and a lack of access to adaptation resources have heavily triggered CAG in northern Ghana and were perceived to offer opportunities for stakeholders by creating connections and interdependence between them. For instance, smallholder famers and businesses in our study region were able to access agricultural inputs and equipment through CAG projects, echoing previous research that highlights the positive link between stakeholder interdependence and cooperation in natural resource management (e.g. Hossu et al, 2018; Berkes, 2010). Indeed, in northern Ghana, CAG projects provided both material and non-material resources needed for climate change adaptation including knowledge exchanges, learning and experimentation aspects of CAG that have also been highlighted elsewhere (Newman and Dale, 2005; Rudnick et al, 2019; Dapilah et al, 2019). CAG projects also facilitated access to human capital and financial resources essential for building adaptive capacity. Regarding infrastructure and access to agricultural equipment, collaboration between actors in CAG made the production of improved seeds and acquisition of tractors and maize-shelling machines possible. Agricultural inputs such as fertilizer and pesticides as well as climate information were made available to our respondents through collaborative arrangement. This led to bridging access to resources deficits and facilitated better adaptation to climate change. These findings align with previous studies that show the close relationship between collaborative governance processes and adaptive capacity (Rudnick et al, 2019; Fabricius et al, 2007; Berkes et al, 2003).

However, despite the positive connections between CAG and adaptive capacity, our results also indicate that CAG projects are beset with challenges in northern Ghana. These include a complex nexus of factors such as coordination and alignment, participation and stakeholder interest, accountability and transparency issues, and sustainability challenges. Previous studies have emphasized the need for coordination and alignments of projects in adaptation planning (Berrang et al., 2019; Asante et al, 2015; Antwi-Agyei et al., 2017). However, as we show in our results, the mechanisms required to facilitate coordination and alignments among different CAG projects in northern Ghana were lacking. This proved to be a major drawback to their success as it hampered interdependence among and between different state-led and NGO-network CAG projects. This meant that expertise and materials needed to promote adaptation were not shared between different CAG projects across community, district and regional levels. Therefore, we add to the existing literature by showing that interdependence thrives when there are mechanisms for the coordination and alignments of different CAG, a point that has received little attention in the literature to date. As observed by Berrang-Ford et al., (2019), tracking how adaptation is taking place allows coordination and alignments of projects, documentation of best practices, and collective experimentation and sharing of lessons about what works, where and why. However, as we show, in northern Ghana, alignment and coordination of different CAG projects proved to be an arduous task for stakeholders involved. This was because stakeholder objectives, interests, responsibilities, funding schemes and time lines differed widely. CAG projects were consequently observed to work side-by-side which resulted in duplication and fragmentation. This lack of coordination and alignment has implications for how scarce climate finances are put to use, which, in turn affect the success and sustainability of all adaptation projects in a certain area. As has been argued in previous studies (e.g. Antwi-Agyei et al, 2017; Asante et al, 2015), the scarce resources available in developing countries must be utilized more effectively to support the coordination of projects and alignment with local development plans. The lack of structured dialogue between state actors and NGOs represents working on various adaptation projects i in this respect a major issue. The governance literature highlights the multiple benefits from exactly such explicit dialogue in collaborative governance processes (Fabricius et al, 2017; Brockhaus et al., 2012; Pahlst-Wolst, 2019).

In addition, these challenges were compounded by participation and stakeholder interests, accountability and transparency issues, diverse interests regarding adaptation options, and finance. All of these factors are identified as crucial to the collaborative governance processes (Driessen et al, 2012; Armitage et al., 2012; Folke et al., 2005). Indeed, many of the CAG projects covered in our results did not meet the basic tenets of collaborative theory. Issues concerning consensus in project conceptualization, participation, transparency and accountability remained major hindrances to their success and sustainability. These issues have also been highlighted in the recent report of the African Development Bank (2019): analysis of the adaptation components of Africa‟s Nationally Determined Contribution (NDCs). The identification of clear stakeholder responsibilities in CAG project design and implementation also affected fair and civil discourse. Likewise challenges of open and inclusive communication and balanced representation of diverse interests, all argued to constitute crucial aspect of CAG (Driessen et al, 2012; Ansell and Gash, 2010). The capacity of different actors to influence project goals and processes was uneven. Powerful state actors and NGOs set the agenda, interpreted and implemented rules, framed problems, set norms and influenced discourses in CAG. In northern Ghana, as elsewhere (e.g. Blüdorn and Deflorin, 2019; Martin and Walters, 2013), a mismatch thus existed between the normative principles of collaborative governance theory and what actually happened on the ground. As such, the robustness of CAG projects was always called into question when any of these challenges emerged, for example, when funding for CAG projects ended. Therefore, more studies are needed on how CAG can be more effective. This paper adds to this literature (e.g. Emerson and Gerlak, 2015; Emerson et al, 2012).

6 Conclusion

The aim of this paper has been to examine CAG initiatives in northern Ghana, highlighted in the literature as important for facilitating adaptation to climate change, particularly in resource-scarce regions. This paper explored why, how and if different CAGs actually achieve this. Climate change impacts on agricultural livelihoods combined with the socio-economic incapacities of the state and NSAs have driven CAG in northern Ghana. In this regard, the leadership of state actors and NGOs was critical in initiating and implementing CAG. CAG provided essential material and non-material resources for adaptation to take root, for example, the facilitation of access to improved crop varieties, equipment, climate services, learning, knowledge exchange, and capacity building opportunities. However, several nested governance challenges including how to represent diverse interest of stakeholders, inadequate funding, problems of trust and commitment, and transparency and accountability issues, had dire consequences on the successes, failures and sustainability of CAG in northern Ghana. As the climate change adaptation scholarship moves forward, we must rethink and reshape how adaptation through CAG is achieved. The insights offered in this paper should be seen in this light.

Chapter V

Synthesis and conclusion

Women ranking climate risks and impacts on their livelihoods

Imoro showing the level of 2014 flood

1 Introduction

Over the last three decades, increasing attention has been paid to how resource-dependent communities in SSA and elsewhere are adapting to climate change and variability. This dissertation is a contribution to this growing field of research through an in-depth case study of Bagri, a small village in the Lawra District of the Upper West Region Ghana. Methodologically, I relied largely on qualitative research approaches, a survey and other participatory methods including ranking, scoring and mapping. Conceptually, I drew on the theoretical literatures on barriers to adaptation, social networks and collaborative governance theory.

In northern Ghana, the effects of climate change have increased over last three to five decades (MESTI, 2013; Yaro et al, 2016). In Bagri, respondents reflected this trend in their understanding of how their village has experienced climate change over the last three decades. For example, in the household survey, about 86.6% of household heads in Bagri believed that annual precipitation had decreased over the last three decades. In relation to temperatures, 88.1% of survey respondents suggested that dry season temperatures had increased and 69.2% suggested that temperatures had increased during the rainy season. Similarly, about 87.4% of respondents claiming the intensity of dry season winds had also increased and 43.4% claimed that the wind intensity had increased in the wet season. These climatic changes were accompanied by climate extremes such drought, floods, windstorms and intense temperatures. For example, over the last two decades, Bagri has experienced five major floods. In the years 2000, 2004, 2010, 2014 and 2018, floods that occurred were related to increases in rainfall during storm events. The perceptions of the villagers corroborate those of formal experts working in state institutions, NGOs and also secondary document sources. For example, climate data obtained from the Ghana Meteorological Agency station in Babile indicate declining rainfall and rising temperature trends since the 1960s. Previous studies show that this climate this trend will continue into the future (MESTI, 2013; Owusu and Waylans, 2009). For example, it is estimated that by 2040 mean annual rainfall will decrease by 3.5%, while mean temperatures will increase by 3.5% in the whole of northern Ghana (Amlalo and Oppong-Boadi, 2015).

Ongoing and intensifying climate change was perceived by respondents to have negatively impacted agricultural production leading to diminishing crop yields. Climate change and related extremes such as prolonged drought, dry spells and floods affected decision making and planning of agricultural activities such as farm preparation, the sowing of seeds, fertilizer and pesticide use. For example, to mention a few effects of climatic changes, crops are increasingly drowned by floods, top-soil is being washed away by heavy rainfall, drought and excessive temperatures are causing high evapotranspiration, and loss of soil moisture and strong winds are breaking maize and millet stalks. Therefore, these changes in the climate required some form of adaptation by stakeholders working at various levels including residents of Bagri. It is this response that the three papers presented here have sought to explore.

In chapter two of this dissertation, the paradox of climate change being a barrier to successful adaptation outcomes is explored. Specifically, we examined the nexus between climate extremes and incremental agricultural adaptations of smallholder farmers. We demonstrated that surmounting non-climatic barriers to the uptake of agricultural adaptation strategies is a necessary but insufficient condition to achieving successful outcomes. We showed that new barriers in the adaptation process are constantly emerging with CCEs being one example.

In chapter three, we engaged the social network and livelihood diversification literature as an analytical position. Mainly, we explored how social networks foster livelihood diversification and resilience during climate change in Bagri. Our results show that engagement in group activities and networks has fostered diversification. This was mainly because households in groups had diverse networks that facilitated their access to the material and non-material resources essential for diversification beyond the reach of individuals. The chapter illuminates how group activities and social networks create diverse pathways and outcomes for adaptive capacity and resilience in a resource-poor community such as Bagri.

Finally, chapter four examined how state actors and non-state actors at various scales work through collaborative initiatives to facilitate adaptation in the case study village and across four districts in the Upper West Region of Ghana. In this chapter, we show that perceived climate change, diminishing agricultural livelihoods, adaptation resource needs and opportunities largely drove collaborative adaptation governance. Our results indicate that collaborative adaptation projects generated immense benefits for adaptation to take root and as well several challenges. We discuss the implications of our findings and provide insight into the extent to which CAG approaches can be reshaped moving forward in order to successfully adapt to the ever-increasing impacts of global climate change.

Overall, this dissertation has provided important interdisciplinary lessons and has advanced the theoretical conception of how vulnerability, adaptive capacity and resilience interact in northern Ghana and beyond (at the village, regional, and national levels). The papers presented achieve this, by demonstrating the different ways in which vulnerability and adaptation strategies of smallholders are connected and how they shape adaptive capacities and resilience during climate change and variability. Chapter three and four highlight how social networks, group activities and collaborative governance processes facilitate new adaptation strategies for enhancing adaptive capacity and resilience. The results highlight the need for robust collaborative governance mechanisms that are sustainable in the sense that they maintain formal social networks and the resources for adaptation that they bring to smallholder farmers. Indeed, the results in chapter four indicate that the lack of sustainable collaborative governance mechanisms has disconnected the social ties between formal institutions and local communities. Moreover, chapter two and three also show that some strategies implemented to enhance adaptive capacities and resilience can also be vulnerable to climate extremes. For example, group activities and networks have created marginalization and exclusion. The cultivation of crops in valleys, horticulture and fuel wood trade have all created different forms of vulnerabilities (e.g. floods, deforestation) in Bagri. While acknowledging that the drivers of and barriers to successful adaptation articulated in the case study village may change in future, I anticipate that many of the issues raised in the three papers will still be relevant in adapting to future climate change and variability. Ultimately, this dissertation, adds to the ongoing and burgeoning climate change adaptation research agenda, particularly in developing countries.

2 Conclusion and future research on climate change adaptation

Throughout the empirical field work and PhD writing processes my engagements with the climate change adaptation community (e.g. researchers, practitioners and policy-makers), several interesting issues that call for critical analysis have emerged that are beyond the scope of this dissertation. The following should suffice to highlight four of these issues.

There is a need for research aimed at arriving at a better understanding of current and future climate change in northern Ghana and SSA Africa in general. As agricultural is the mainstay of a majority of rural households in the region, the negative impact of climate change on

agricultural livelihoods remains a daunting challenge that deserves urgent attention. Chapter two of this dissertation covers this problematic issue. It shows that increasing climate extremes that accompany climate change have prevented the effective implementation of incremental adaptation strategies by smallholder farmers in Bagri. This often led to low crop yields and financial indebtedness. Meanwhile, there is no accurate understanding of current and future climate change and climate extremes in SSA. This situation is coupled with the lack of climate services and information. To address this challenge, I propose massive investment and research aimed at developing appropriate technological innovations in climate prediction and information delivery that is integrated with local knowledge of communities in SSA. This should be linked with increased research into the development of new and improved seed varieties that can withstand the effects of the changing climate. Research and the development of innovative financial schemes and climate index insurance schemes tailored to the needs of smallholder farmers are also urgently needed to facilitate adaptive capacities and resilience to climate change in the global south and SSA in particular.

A second broad research challenge, relates to the need to integrating the socio-spatial dimensions of networks, dialectical and feedback processes between areas of origins and destination (Rockenbauch and Sakdapolrak, 2017). In addition, the specifics of how climate change reshapes new communities, boundaries and the implications for adaptive capacities of actors in both origin and destination are still yet to be understood in the Global South. As shown in chapter three of this dissertation, social relations and networks that form in response to climate change have multiple boundaries. In response to climate change, the people of Bagri have formed diverse networks across temporal and spatial scales. Arguably, this makes it difficult to define Bagri as a place-based community. Indeed, Bagri is embedded in networks at distant places that have feedbacks and implications on how they adapt to climate change. However, as it stands now, the current literature on climate change adaptation emphasizes the structure of networks over agency and social relations in place-based communities (e.g. Bodin et al, 2006; Bodin and Prell, 2011). Against this backdrop, I propose future research on climate change adaptation in developing countries from the perspective of translocal resilience (Sakdapolrak, 2017). This perspective explores the simultaneous embeddedness of social actors through their daily activities and multiple forms of mobility that span different locales (Brickell and Datta, 2011; Greiner and Sakdapolrak, 2013). It focuses on the role of translocal networks in conditioning the capacity of particular actors, households, and communities for coping with and adapting to changes, transforming livelihoods, and exploring alternative modes of social-ecological interaction (Sakdapolrak, 2014, Sakdapolrak et al., 2016).

Moving forward and in addition to the two mentioned above, there are still, several adaptation governance gaps that need to be addressed. Issues of coordination, alignment and tracking of adaptation progress have been raised in chapter four of this dissertation. More research is needed to help in our understanding of these issues. This is because as more climate change adaptation research and practice occur, it is increasingly expedient to involve different stakeholders working on multiple issues that cross temporal and spatial scales (Klein et al., 2017). In this regard, it is of particular importance that we reach a clear understanding of individual and collective interests, including the roles and responsibilities of different actors in adaptation governance. For example, there is still little understanding of how public and private interests can be harnessed to facilitate climate change adaptation. There is an urgent need for actors operating at scales or layers: bottom-up, top-down, global and local, to share information and experience on these problematic themes in adaptation research.

Finally, the financing of adaptation still remains problematic despite efforts on various fronts and efforts by global-local and public-private sectors to close this gap through various

financing schemes in developing countries. In chapter four, we showed that collaboration between public-private actors is a means to bridging gaps in adaptation finance. However, such measures are often ephemeral and unsustainable in the long term. One way forward would be to gain a better understanding of how adaptation supply and demand chains in capitalist and market oriented models are delivered in developing countries. This should in addition include research into issues of equity and social justice in the delivery of adaptation measures in developing countries. For example, if private business and industries are both creators of environmental problems while also being custodians of technology and the knowledge needed to facilitate environmental sustainability: (i) who should bear the final cost of adaptation, (ii) why should the cost of adaptation be imposed on poor smallholder farmers when they did not contribute to climate change emissions, and (iii) how should the private sector fund adaptation in a socially just manner within a neo-liberal market system? Future research needs to explore these theoretical and ethical insights in developing countries.

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Appendixes

Appendix 1: Questionnaire for Household heads

1. Household characteristics

a. Interviewer Name:	c. Household code:
b. Respondent Name:	D1. Sex of respondent D2. Age : Male [ ] Female [ ]

e. Relation of respondent to household head f. Ethnicity of household

1. Household head [ ] 2. Wife of household head [ ] 3. Other [ ]

h.1.Rank occupations of household members in order of importance

(1-most important……8=least important, 0= no source of income for any household member

h.2. Indicate whether the activity is especially performed by men or women, if there is no difference thick both

h.1.main activities of the household		h.2: performed by men or women	
		men	women
Crop farming			
Animal husbandry			
Fisheries			
Day labour within agriculture			
Off-farm labour (non-agriculture)			
Agro-processing			
Commerce and trade			

Civil servant			
other			

g. Number of years the household occupies this residence……..

2. Household Composition and household characteristics

This question deals with the household members who are currently living with the household and those who migrated for less than 12 months.

a. What is the sex of the household member? Tick male or female
b. What is the age of household member?
c. Did the household members migrate for a period of less than 12 months during the last year? Tick yes or no.

Household member …… ……..	(a) sex		(b) Age	(c) Temporary		(d)Years of education
	(i) Male	(ii)Female		(i) Yes	(ii) No	
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

2.e. Are there any household members who belong to the household but who have migrated permanently? Note that these do not refer to household members who left the household to start their own household somewhere else. It refers eg. A husbands or wives who migrated permanently with the objective to send cash to the village

Yes	No

If answer is yes, ask which people migrated permanently and to where (name of town)-
……
……

3. Livelihood Decisions and Crops Cultivated

a. What are the determinants of your household livelihood decisions and strategies in a year? List them in order of importance (1-most important……5=least important)(eg. Capital, weather information, labour, access to land, farm inputs)

Factors that influence household livelihood decisions in a year		Rank
1		
2		
3		
4		
5		

b. Briefly comment on the ranking in 3a.

……
……
……
……

c. Did you cultivate any of the crops listed below during last 12 months? (Tick if the crop is grown)

d. How much land did you cultivated with each of these crops?

e. From which crops harvested during last 12months did you sell a part? (tick yes or no). if crops are sold asked whether the money is managed by men or women. Tick cells „men" and „women"

f. How much land do you own or have permanently for cultivation... (Unit)

g. Does the household own livestock or poultry? Tick (yes/no)

h. How many livestock/poultry does the household currently owns?

	(c)	(d)Land cultivated		(e)			(g)			(h)			
Code	Crops	amount	unit	yes	No	men	women	code	Livestock/ poultry	1-4	5-9	10 +	
1								1					
2								2					
3								3					

4								4					
5								5					
6								6					
7								7					

4. Fisheries and Agro-processing

a. Does the household engage in fishing? Tick, Yes ( )
No ( )

b. Did you sell any fish during the last 12 months? Yes ( )
No ( )

c. Does the household process agro-foods such as sheabutter? Yes ( )
No ( )

d. Did you sell any of these processed products within the last year? Yes ( )
No ( )

5. Major Household assets

Item	(a) Asset owned		If (a) is yes : b number of assets owned
	(i)Yes	(ii)No	
Tractor			
Car/bus			
motorcycle			
Bicycle			
Mobile phone			
Television			
Radio/sound system			
Gas/petrol stove			
Refrigerator			
Others			

6a. Climate change

a1. Have you experienced a change in climate over the past 30 years? i. Yes ( ) ii. No ( )

a2. If yes how has it changed? i. increased ii. No Change iii. Decreased iv. No answer

a3. How frequent is this change? 1. Slow 2. Fast 3. Can‟t tell

a4. Have your lifetime periods been characterized by more or less favorable rainfall or temperatures? (tick, yes/no)

a5. If you experienced the hazard, can you indicate when this has taken place or do you know of important events that have taken place during those periods?

code	Climate risks	Climate risk		If (a) is yes: (b) Years/period event took place
		Yes	No	
1	Less rainfall during rainy season leading to drought			
2	Period of prolonged drought leading to crops drying out or livestock not having sufficient water or grass			
3	Excess rainfall leading to floods			
4	Too heavy showers leading to damage to crops, livestock and property			
5	Periods of extreme temperatures, leading to scorched crops			
6	Flooding as a result of the opening of the Bagri dam in Burkina-Faso			

a1.Climate Parameters		a2(i) Increased	a2(ii) No Change	a3(iii)Decreased	a4(iv) No change	Rate of change
Precipitation	Annual					
	Rainy season					
	Dry season					
	Length of dry spells rainy season					
	Intensity of rainfall events					
	Inundation of fields and villages					
Temperatures	dry season temperatures					
	Rainy season temperatures					
	Length of cold periods					
	Length of hot periods					
Wind	Intensity, dry season					
	Intensity, rainy season					

6b. Causes of climate change variability and Access to climate and weather information

b1. What are the causes of climate change variability in this community? (tick)

b2. Have you had access to climate information over the past five years? Yes ( ) No ( )

b3. If yes, from which source(s)?
b4. How reliable is the climate source in given you accurate weather information? (1-Not reliable,2-less reliable, 3-moderate,4- more, 5-very reliable)

(b1)Causes	(b2)Access		(b3)Source	(b4) Reliability
	Yes	No		
1.			1.	
2.			2.	
3.			3.	
4.			4.	
5			5	

b5. Does this weather information received from the source(s) make you to adapt better to climate change variability?

……
……
……

b6. In your view, do you think the climate and weather conditions will improve in the near future?

……
……

6c. Climate change impacts on livelihood

C1. For those climate related hazards/risk that you have experienced, to what extent did you experience effects in your activities (0=not applicable, 1= a lot less, 2= less, 3= no change, 4 =more, 5 = a lot more)

(a)Effects of hazards on livelihoods	(C1a) Crop production	(C1b) Area cultivated	(C1c) Livestock owned	(C1c) Assets owned	(C1d) Other agro-based products	(C1e) Cash-income
Less rainfall during rainy season leading to droughts						
Periods of prolonged drought leading to crops drying out or livestock not having sufficient grass and water.						
Excess rainfall leading to floods						
Too heavy showers leading to damage to crops, livestock and						

property						
Periods of extreme temperatures, leading to scorched crops						
Flooding as a result of the opening of the Bagri dam in Burkina-Faso						

C2. To what extent do these hazards have catastrophic consequences on your livelihoods? (0=not applicable, 1= a lot less, 2= less, 3= no change, 4 =more, 5 = a lot more)

C3. To what extent are you able to predict the occurrence of these hazards in a year? (0=not applicable, 1= a lot less, 2= less, 3= no change, 4 =more, 5 = a lot more)

C4. To what extent are you able to adapt to the occurrence of these hazards in a year? (0=not applicable, 1= a lot less, 2= less, 3= no change, 4 =more, 5 = a lot more)

C5. If you compare the situation in the last 10 years with the period before, have the hazards become catastrophic, predictable, and adaptable? Tick Yes/No

C6 Do you think some households in this community are resilient to the climate risk mentioned than your household? Explain

……
…….

Hazards	rating			(C51) More threat		(C52) Less predictable		(C53) Difficult to cope/adapt	
	Catastrophic (C2)	Predictability (C3)	Adaptability (C4)	Yes	No	Yes	No	Yes	No
Less rainfall during rainy season leading to droughts									
Periods of prolonged drought leading to crops drying out or livestock not having sufficient grass and water.									
Excess rainfall leading to floods									

Too heavy showers leading to damage to crops, livestock and property									
Periods of extreme temperatures, leading to scorched crops									
Flooding as a result of the opening of the Bagri dam in Burkina-Faso									

8. Community capacity to manage Resilience

a. To what extent is this community able to perform the following collective actions in cases of the hazards mentioned previously? (1=Not at all, 2=less, 3= neutral, 4= more, 5=greater)

b. To what extent will you say this collective action of the community has helped your household in building your resilience? (1=Not at all, 2=less, 3= neutral, 4= more, 5=greater)

c. In your view, do you think some groups/ people benefit from the collective actions than others in the community?

Areas of collective action	(a)	(b)	(c)		(d)
	Rank	HH resilience	Yes	No	
1.Disaster risk reduction					
2.Conflict management					
3. Social protection					
4. Natural resource management					
5.Management of public goods					

d. If yes to the above which groups/ people?

Briefly comment on the above rankings

……
……
……..

9. Household and Translocal network

a1. With which institutions and individuals does your household have contact?

a2. Where are they located?

b. If you have been in contact with an organization/ individual, how often do you have contacts? (1=never, 2=occasionally; 3=during the growing season,4=a few times per year, 5=a few times per month, 6= every week)

c. If you have been in contact with the organization/individual, since when have you been contacting the specific organization?(1=this year, 2= last year, 3= five years ago, 4= ten years ago, 5= more than 10 years)

d. Is it possible to link the date since when households are in contact with an individual or institution with the data since when a hazard is experienced as discussed in 6 A5 (numbered 1-6)

e.If you have been in contact with the organization, has the assistance from them helped your household to be resilient to the natural hazards that are a danger to your household?

Organization/individual	(a1) In contact		(a2) location		(b) Frequency of contacts with institutions	(c) Have been in contact since	(d) Link to hazards in question . 6	(e) Helpful for resilience	
	Yes	No	Inside	outside				Yes	No
1.Family member/friend									
2. Business									
3. Government institution									
4.International donors									
5.Non-Governmental organizations									
6. Traditional Institutions									
7. Cooperatives									
8.Banks									
9.Religious groups									
10. Micro-finance groups									
11. Women groups									
12. Self-help groups									
13. Others……..									

Please, explain point e in the table above

……
……
…….

f. What form of exchanges took place between you and the Organization/individual?

rganization/individual	Type of exchange between household and organizations/individuals					
	f(i)Cash	f(ii) food	f(iii)Farm-input	f(iv)information	f(v)Training	f(vi)other
1.Family member/friend						
2. Business partners						
3. Government institution						
4. International donors						
5.Non-Governmental organizations						
6. Traditional institutions						
7. Cooperatives						
8. Banks						
9.Religious groups						
10. Microfinance groups						
11. Women groups						
12. Self-help groups						

g. How will you rate the contribution of **each** of the institutions in shaping your resilience to climate risk? (Scale of 1(less)-5(more) on the following:

g(i) competence (1-Not, 2-less, 3-moderate, 4- more, 5- a lot more)

g(ii) fairness(1-Not, 2-less, 3-moderated, 4- more, 5-a lot more)

g(iii) consistent(1-Not, 2-less, 3-moderate, 4- more, 5- a lot more)

g(iv) sincerity (1-Not, 2-less, 3-moderate, 4- more, 5- a lot more)

g(v) Empathy(1-Not, 2-less, 3-moderate, 4- more, 5- a lot more)

h. Which of these institutions do you perceive as Trustworthy?

Organization/individual	(g)rating of institutions in shaping resilience to climate risk Trustworthy					(h)	
	g(i)Competence	g(ii)fairness	g(iii)consistent	g(iv)sincerity	g (v)Empathy	Yes	No
1.Family member/friend							
2. Business/commercial firms							
3. Government institution							
4. International donors							
5.Non-Governmental organizations							
6. Traditional institutions							
7. Cooperatives							
8. Banks							
9.Religious groups							
10. Microfinance groups							
11. Women groups							
12. Self-help groups							
13. others							

Please, kindly comment on the above ratings

……
……
…….

10. Major strategies of households to cope with climate change and varuiabity

a. Do you apply the adaptation options given below in order to adapt to the hazards given in the previous questions? Who decided about the strategy change, one of the men or women of the household?

b. If adaptation strategy is opted, which of the hazards are reduced? (1=Drought due to less rainfall during rainy season; 2= Periods of prolonged drought leading to crops drying out or livestock not having sufficient grass and water; 3= Excess rainfall leading to floods; 4= Too heavy showers leading to damage to crops, livestock and property; 5= Periods of extreme temperatures, leading to scorched crops, 6= Flooding as a result of the opening of the Bagri dam in Burkina-Faso

Strategy type	(a) Strategy adopted				(b) Which hazards are reduced?						Strategy type					(b) Which hazards are reduced?					
	Yes	No	Men	women								Yes	No	Men	women						
AGRICULTURAL TECHNIQUES											**C. DIVERSIFICATION**										
A1. Crop selection					1	2	3	4	5	6	C1. Temporal migration to cities					1	2	3	4	5	6
A2. Adapt planting dates					1	2	3	4	5	6	C2. Temporal migration to rural areas					1	2	3	4	5	6
A3. Adapt cropping densities					1	2	3	4	5	6	C3. Permanent migration(urban-rural)					1	2	3	4	5	6
A4. adapt fertilizer/pesticide application					1	2	3	4	5	6	C4. Non-timber forests product commercialization					1	2	3	4	5	6
A5. Adapt tillage practices					1	2	3	4	5	6	C5.Home garden agriculture					1	2	3	4	5	6
A6.Change pastoral system(distance and frequency of mobility)					1	2	3	4	5	6	C6. Increased market sales					1	2	3	4	5	6
A7. Change the herd composition					1	2	3	4	5	6	C7. Handicrafts					1	2	3	4	5	6
A8.Apply different feed technique. Eg. Zero grazing					1	2	3	4	5	6	C8.Charcoal or timber sales					1	2	3	4	5	6
A9. change from pastoral to sedentary agricultural system					1	2	3	4	5	6	C9. Start fisheries					1	2	3	4	5	6
A10.improve food storage facilities					1	2	3	4	5	6	C10.Reduce expenses by changing consumption(type and number of meals					1	2	3	4	5	6

B.WATER MANGEMENT											C11. Draw on livestock, surpluses or savings					1	2	3	4	5	6
B1. Use water harvesting techniques: roof water collection, tanks					1	2	3	4	5	6	**D. COMMUNAL POOLING**					1	2	3	4	5	6
B2. Improve, construct or rehabilitate terraces											D1. Restore homestead or forest to reduce erosion					1	2	3	4	5	6
B3. Use irrigation											D2. Rangeland preservation and grazing restrictions					1	2	3	4	5	6
B3. Improve watering sites in pastoral areas											D3. Communal water harvesting										

Appendix 2.

Major Crops Grown		**Major livestock/Poultry**	
Code	**Crops**	**Code**	Livestock and poultry
1	Maize	1	Cattle
2	Sorghum	2.	Goat
3	Millet	3	Sheep
4	Cowpea	4	Pig
5	Groundnuts	5.	Fowls
6	Soyabean	6.	Guinea fowls
7	Rice	7	Ducks

code	**Climate risk**
1	Less rainfall during rainy season leading to drought
2	Period of prolonged drought leading to crops drying out or livestock not having sufficient water or grass
3	Excess rainfall leading to floods
4	Too heavy showers leading to damage to crops, livestock and property
5	Periods of extreme temperatures, leading to scorched crops
6	Flooding as a result of the opening of the Bagri dam in Burkina-Faso

a. **Competence**- ability to do something efficiently or successfully

b. **Fairness-** Impartial and just treatment, without favouritism

c. **Consistency**- Quality of performance which does not vary in quality greatly

d. **Sincerity-** The absence of deceit or pretence

e**. Empathy**- The ability to share and understand the feelings of another.

Declaration

Mathematisch-Naturwissenschaftliche Fakultät
Akademische Angelegenheiten

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According to the regulations for the award of a doctoral degree of the Faculty of Mathematics and Natural Sciences 2018:

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Frederick Dapilah